INCAP Publication I-1245

Journal of Tropical Medicine and Hygiene 1981, 84, 243–248

Criteria for selection of communities in poor rural areas with high risk of low birth weight babies

J. M. Belizán, H. Delgado, V. Mejia-Pivaral, V. Valverde and R. E Klein

Division of Human Development, Institute of Nutrition of Central America and Panama (INCAP), P.O. Box 1188, Guatemala, Guatemala

Introduction

Low birth weight (LBW) (weight $\leqslant$2.500 g) represents one of the greatest public health problems in developing countries.

Estimates made in 1975 showed the rate of low birth weight babies in developing countries to be 19% while in industrialized countries it was approximately 7.4% (Lechtig *et al.* 1977). Low birth weight children have a neonatal mortality rate 20 to 40 times greater than those with an adequate weight at birth (Chase 1967, Puffer & Serrano 1975, Mata *et al.* 1977) and their infant mortality rate is also 10 to 15 times higher (Chase 1967). Neurological studies of school age LBW children demonstrated that between 40 and 60% of these children had retarded motor development and neurological abnormalities (Fithardinge & Steven 1972, Bjerre 1975).

Given the seriousness of the problem, it is vital that those groups or populations at risk be identified, in order to implement active programmes in them which would tend to improve birth weight. A series of studies have evaluated individual high-risk factors which facilitate the selection of pregnant women with the greatest probability of giving birth to a LBW baby (Nesbit & Aubry 1969, Lechtig *et al.* 1976). Nevertheless, neighbouring populations are observed, such as those reported in this study, which have similar characteristics (race, income, eating habits, environmental sanitation, etc.) and which, in spite of these similarities, show great differences in the incidence of low birth weight babies. For this reason, identification of populations with greater risk of low birth weight babies using simple indicators is important in order to establish priorities for health activities.

Correspondence: Dr J. M. Belizán.

Materials and Methods

The study populations are made up of rural workers in coffee plantations (fincas) on the Pacific coast of Guatemala, in Central America. In these communities, a project involving health and nutrition intervention is being carried out by the Human Development Division of the Institute of Nutrition of Central America and Panama.

All the inhabitants are contracted and provided with housing by the finca owner. The main source of income is provided by the finca owner and the wage per job completed is the same in all the communities. Other minor sources of income would include marketing of home-produced goods (fruits, tortillas, sewing, animals, etc.).

The total population under study consists of 6595 inhabitants living in 10 different communities. The smallest community has 273 residents and the largest 1369 (Table 1). In the area where these communities are located, there is a total of about 40 000 workers living in the same conditions as the population under study.

On a day's trip through these communities, similarities in aspects such as housing construction, dress style (predominantly Indian), unpaved access roads and climate (hot with a 6-month rainy season) are easily observed. Also, each community has a small public school and they all have the same source of income.

More detailed population data for the distinct communities are shown in Table 1. Some of this information was collected by a retrospective census, some by means of longitudinal interviews and the rest by prospective compilation. All the information was collected in a 1-year period between October 1977 and October 1978. In this interval, a total of 302 single births were studied. The birth weight was measured in the home during the first 24 h of life since, as is

0022–5304/81/1200–0243 $02.00

customary in these communities, all were home deliveries.

Infant mortality was measured by means of a maternal retrospective survey covering the previous 5 years. The family history method (Bogue & Bogue 1970), which has proved to be effective (Potter 1977), as well as a check of the birth records kept in the fincas and neighbouring villages, have been carried out in order to compensate for memory failure. Height measurements were taken for all pregnant women during the year of the study. The patients were weighed in the first trimester of pregnancy before the thirteeth week. Their caloric intake was measured by means of a 24-h recall survey of the family diet in which the foods were weighed, and measurement examples were used to aid housewife's memory. For analysis purposes, all women for whom recall data was available in the first and third trimester of pregnancy were taken into consideration. The prevalence of smoking mothers was calculated by a cross-sectional recall which asked if cigarettes had been smoked in the 3 days prior to the interview and which included both pregnant and nursing mothers.

The annual *per capita* income was taken from the pay records of the finca for the study period, which, as mentioned before, is the main source of income for these populations, accounting for more than 90% of their total income.

In each community, the percentage of houses which had the kitchen inside the sleeping area was calculated relative to the total number of houses. In the study communities, firewood is used for cooking, with the open fire being kept going all day long; no chimneys are used. Some houses have only one room which serves as a kitchen and sleeping and living areas in which the mother spends the major portion of her day. In other houses the kitchen is separate from the rest of the house and the mother spends there only the time dedicated to food preparation. All the houses of the finca workers are constructed by, and belong to, the owner of each finca. The construction is arbitrary and does not follow a plan, but within the finca there is usually a great deal of uniformity.

It is because of this that there are great variations in the location of the kitchen between fincas, but not within fincas (Table 1). The finca owner assigns the finca dwellers to a house and can move them arbitrarily. The distinct families generally do not make any major changes in, or build on to their dwelling, as it does not belong to them and they are subject to frequent housing changes ordered by the finca owner.

In order to catalogue a family as being Indian, the dress style and language spoken in the home were taken into account. For this variable and the literacy level, information is not available for two communities, making the number of cases studied eight rather than ten.

Accessibility to villages was evaluated using three criteria: distance from the village, frequency of public transportation and proximity to public transportation. The scores ranged from 1 to 5, with the higher value indicating greater access to villages. Villages have a public market, sources of amusement and relatively complete health facilities, all of which are lacking in the study communities.

For all the descriptions and comparisons, each community was taken as a unit so that every community is represented by one value in the analyses, with that value being the mean for each variable.

Results

The principal characteristics of the communities are described in Table 1. Indicators exist which show a great variability among fincas (more than 50%) such as the incidence of low birth weight, the percentage of smoking mothers, and the percentage of houses with the kitchen in the sleeping area. The annual income showed a variability coefficient of 29%. Little variability exists in the literacy rate, in the percentage of Indian families, and in the weight and height of pregnant mothers (Table 1).

In Table 2 the correlations found between distinct characteristics of the communities and birth weight can be observed. Statistically significant correlations between birth weight and the following variables were found: weight in the first trimester of pregnancy, caloric intake in the first and third trimester of pregnancy, prevalence of houses with the kitchen in the sleeping area, prevalence of literacy, and ease of access to neighbouring villages. The *per capita* income did not demonstrate a significant correlation at 5% even though the tendency observed is the expected one, with a positive coefficient of 0.533 with average birth weight and a negative coefficient of −0.279 in relation to the incidence of low birth weight. This concordance is seen in the other characteristics studied which did not have statistical significance, such as the height of

Table 1. Characteristics of the communities

Variable		No. of communities	Average	Standard deviation	Coefficient of variability (%) among communities	Ranges of the communities
Average birth weight (g)		10	2946	464	16	2780–3600
Incidence of low birth weight (< 2500 g) (%)		10	17.16	12.3	72	0–43.8
Retrospective infant mortality (last 5 years) (%)		10	161.5	36.1	22	93–202
Height of pregnant women (cm)		10	143.1	5.1	4	141.2–145.1
Weight in first trimester of pregnancy (kg)		10	46.2	2.7	6	42.1–51.9
Daily caloric intake during pregnancy (kcal)	First trimester	10	2010	571	28	1620–2198
	Third trimester	10	2007	620	31	1638–2272
Prevalence of smoking mothers (%)		10	9.0	7.9	87	0–25.8
Number of inhabitants		10	643.1	364.6	57	273–1369
Annual *per capita* income (dollars)		10	140.7	40.2	29	92.0–215.3
Prevalence of houses with kitchen in sleeping area (%)		10	37	22.6	61	11–65
Literacy rate (%)		8	31	5.6	18	24–42
Proportion of Indian families (%)		8	80	11.9	15	59–95

Table 2. Correlation between different characteristics of the communities and birth weight

Variable		No. of communities	Average birth weight r	b	Incidence of low birth weight (< 2500 g) r	b
Height of pregnant women (cm)		10	0.418	69.5	−0.324	−2.91
Weight of first trimester of pregnancy (kg)		10	0.677†	56.2	−0.641*	−2.87
Daily caloric intake in pregnancy	First trimester	10	0.411	0.54	−0.613*	−0.044
	Third trimester	10	0.444	0.48	−0.746‡	−0.044
Prevalence of smoking mothers (%)		10	−0.025	−0.72	0.021	0.033
Annual *per capita* income (dollars)		10	0.533	3.03	−0.279	−0.086
Prevalence of houses with kitchen in sleeping area (%)		10	−0.715‡	−7.8	0.748‡	0.46
Literacy rate (%)		8	0.857‡	38.2	−0.700*	−1.56
Proportion of Indian families (%)		8	−0.564	11.9	0.520	0.55
Accessibility of villages		10	0.52	87.8	−0.78‡	−7.09

* $P < 0.05$; † $P < 0.025$; ‡ $P < 0.01$.

pregnant women and the prevalence of Indian families. The prevalence of mothers who smoked showed a very low correlation (Table 2).

Discussion

The relation found between the variables studied and birth weight on a community level coincides with various reports in the literature of studies of individuals. Thus, it has been seen that preconceptional height and weight, or that of the first trimester, have a positive correlation with birth weight (Butler & Alberman 1969, Fedrick & Adelstein 1978). In spite of the low variability in maternal weight in the first trimester, this was associated significantly with birth weight. Other studies have demonstrated the direct relation between maternal food intake and birth weight (Lechtig *et al.* 1975) which is also seen in this community study. The coefficient of correlation is very high, especially for the diet in the third trimester. From the analysis of the slope it can be deduced that an average increase of 100 calories daily would produce a 4.4% reduction in the incidence of low birth weight infants.

The low correlation observed in the prevalency of smoking women could be due to the fact that the data was collected cross-sectionally and does not reflect the reality of the entire pregnancy. Also the number of cigarettes smoked by these women was very low, with no one having smoked more than two cigarettes daily.

It is interesting to note that the location of the kitchen is related significantly to birth weight. In laboratory animals it has been demonstrated that carbon monoxide causes reduction of fetal growth (Astrup *et al.* 1972). In women, indirect information is available concerning the effect of carbon monoxide on fetal development by means of studies of women who smoke (Butler & Alberman 1969, Astrup *et al.* 1972) and of inhabitants of areas with high carbon monoxide concentration (Williams *et al.* 1977). The pregnant woman in communities with a high percentage of houses with the kitchen inside the sleeping area experiences a high exposure to CO, not only in her own house, but also in the houses she visits.

In a study carried out in dwellings similar to those described, it was seen that the carbon monoxide (CO) concentration in the kitchens had a mean value during the entire day, due to the continual presence of the cooking fire of 30.7 ppm (SD = 16.9) with high values (up to 50–70 ppm) during the time in which meals were prepared (Dary 1979). Values of 30 ppm during waking hours are three or four times higher than the internationally accepted permissible values (Wright *et al.* 1975). Therefore, the maternal carboxyhaemoglobin had an average value of 2.42 (SD = 1.05) (Dary 1979), which is more than two times higher than that found in non-smoking women (Longo 1976).* Extrapolations of the values found in these similar populations would explain why pregnant women subjected during their entire pregnancy to these CO levels might show a deterioration in fetal growth and thus explain the association found in the study populations. It is useful to note that the location of the kitchen is not an indicator of socioeconomic level since the dwelling is constructed by the finca owner and no significant correlation was found between *per capita* income in the community and percentage of houses having the kitchen in the sleeping area ($n = 10$; $r = 0.264$; $P > 0.05$).

The literacy rate in each community had a high correlation with birth weight in spite of the slight variability shown for this indicator. This information takes on particular importance given that, in spite of the existence of an equal wage per job completed in all of the communities, a greater degree of literacy was related to a greater *per capita* income ($r = 0.789$; $P < 0.05$), which might be explained by the family having a greater awareness of its work capacity and a greater ambition, leading to a greater work production. In the same way, a higher literacy rate could be the explanation for a better diet, and, although it was not evaluated in this study, a greater utilization of health services.

The percentage of Indian families is closely related to literacy ($r = 0.70$; $P < 0.05$), which would imply that increased education accompanies a decline in traditional Indian customs.

In spite of the fact that the communities are close to each other and all located within a 200 km^2 area, ease of access to villages, which is represented by their proximity and the availability of public transportation, is associated significantly with birth weight.

This paper offers information which could facilitate the detection of communities which, although similar to their neighbours, have a greater risk of producing low birth weight infants. Some of the indicators which are associated significantly with birth weight are easily investigated. For example, the evaluation of ease of access to villages does not require great expense, nor effort, and is a factor which was significantly related to birth weight. Thus, in planning a programme of aid to rural areas, the sanitary, nutritional and educational activities should be aimed initially at the most isolated communities and those with least access to villages. The degree of literacy is an easy parameter to measure by interviews and is very useful for identification of high-risk communities. Health activities should be combined with a vigorous educational programme since the impact of improving literacy levels is striking. In the study communities, a difference of 10% in the literacy rate accounts for a difference of 382 g in the average birth weight and a 15.6% decrease in the incidence of low birth weight babies in the community.

In populations lacking modern technology in cooking methods, which implies a high rate of smoke production, measures should be taken to reduce the inhalation of CO by use of chimneys and separate, well-ventilated kitchens. In the study communities, the separation of the kitchen from the sleeping area in 10% of the houses

would produce an increase in the mean birth weight of 78 g and a reduction of 4.6% in the incidence of low birth weight infants.

Another activity of great importance for improving birth weight is the increase in the caloric intake of pregnant women. An increase of an average of 100 calories daily in the pregnant women's diet in the study communities would produce an increase in the mean birth weight of between 48 and 54 g, and a 4.4% reduction in the incidence of low birth weight.

The study population is characterized by extremely poor health, nutrition and education conditions, and also a very low *per capita* income. Energetic action should be taken in order to improve these conditions. The identification of those communities which require priority can be accomplished using simple indicators such as degree of literacy and ease of access to villages. For health activities to have a significant impact, they should be combined with nutrition and education programmes, improvement of sanitary conditions and the means of access to population centres, and logically, a substantial income increase.

Summary

In planning public health activities to reduce the incidence of low birth weight babies (LBW) in poor rural areas, it is necessary to identify the communities which require priority actions. The study population consisted of ten rural communities with similar characteristics. All were composed of coffee plantation workers with the same source of income, similar dwellings and dress, and all were located in the same climatic zone. However, the communities showed a variability of 72% in the incidence of LBW babies. Birth weight in the communities was significantly associated with maternal weight in the first trimester of pregnancy, daily caloric intake in the first and third trimesters of pregnancy, prevalence of houses with the kitchen in the sleeping area, literacy rate and ease of access to villages. Thus, the identification of communities which would require priority in public health activities can be accomplished using simple indicators. Health activities should be combined with nutrition and education programmes and improvement both of sanitary conditions and of the means of access to population centres.

Acknowledgements

This project is funded by AID, Contract No. TA-931-17-560-625-73.

References

Astrup P., Olsen H. M., Troell D. & Kjeldsen K. (1972) Effect of moderate carbon monoxide exposure on fetal development. *Lancet* ii, 1220

Bjerre I. (1975) Neurological investigation of 5-year-old children with low birth weight. *Acta Paediatrica Scandinavica* 64, 859

Bogue D. J. & Bogue E. J. (1971) *Techniques of Pregnancy History Analysis.* Community and Family Study Center of the University of Chicago (Family Planning, Research and Evaluation Manual Number 4), Chicago

Butler N. R. & Alberman E. D. (1969) *Perinatal Problems. The Second Report of the 1958 British Perinatal Mortality Survey.* E & S Livingstone, Edinburgh

Chase H. C. (1967) Infant mortality and weight at birth: 1960 United States birth cohort. *American Journal of Public Health* 59, 1618.

Dary M. O. (1979) *Grado de Contaminación por CO Dentro de la Cocina Rural Guatemalteca en Relación a las Costumbres y Materiales de Construcción.* Informe de Investigación. Guatemala, Facultad de Ciencias Químicas y Farmacia, Universidad de San Carlos de Guatemala.

Fedrick J. & Adelstein P. (1978) Factors associated with low birth weight of infants delivered at term. *British Journal of Obstetrics and Gynaecology* 85, 1

Fithardinge P. M. & Steven E. M. (1972) The small-for-date infant. I. Later growth patterns. *Pediatrics* 49, 671

Lechtig A. *et al.* (1975) Effect of food supplementation during pregnancy on birth weight. *Pediatrics* 56, 508

Lechtig A. *et al.* (1976) A simple assessment of the risk of low birth weight to select women for nutritional intervention. *American Journal of Obstetrics and Gynaecology* 125, 25

Lechtig A. *et al.* (1977) Low birth weight babies: world wide incidence, economic cost and program needs. In *Perinatal Care in Developing Countries,* eds G. Rooth & L. Engström. University of Uppsala, Sweden

Longo L. D. (1970) Carbon monoxide in the pregnant mother and fetus and its exchange across the placenta. *Annales of the New York Academy of Science* 174, 313

Mata L., Urrutia J. J. & Mohs E. (1977) Implicaciones del bajo peso al nacer para la salud pública. *Archives of Latinoamerican Nutrition* 27, suppl. 1, 198

Nesbit R. E. L. Jr & Aubry R. H. (1969) High-risk obstetrics. II. Value of semiobjectives grading system in identifying the vulnerable group. *American Journal of Obstetrics and Gynaecology* 103, 972

Potter J. E. (1977) Problems in using birth-history analysis to estimate trends in fertility. *Population Studies* 31, 335

Puffer R. R. & Serrano C. V. (1975) *Maternal Age, Birth Order, and Birthweight: Three Important Determinants in Infant Mortality*. Pan American Health Organization (PAHO Scientific Publication No. 294), Washington DC

Williams K., Spence M. A. & Tideman S. C. (1977) Implications of the observed effect of air pollution on birth weight. *Social Biology* 24, 1

Wright G. R. *et al.* (1975) Carbon monoxide in the urban atmosphere. *Archives of Environmental Health* 30, 123