Impact of nutrition education and mega-dose vitamin A supplementation on the health of children in Nepal

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The impact on vitamin A deficiency (VAD), wasting malnutrition, and excessive childhood mortality of two alternative approaches — nutrition education and mega-dose capsule distribution (6–12-month-olds: 100 000 IU; 1–5-year-olds: 200 000 IU) — in communities in Nepal are compared. Approximately 40 000 children from 75 locations in seven districts in two ecological settings (lowland and hills) took part in the study and were randomly allocated to intervention cohorts or a control group.

At 24 months after the implementation of the project the reduction of risk for xerophthalmia was greater among children whose mothers were able to identify vitamin-A-rich foods (relative risk (RR) = 0.25; 95% confidence interval (CI) = 0.10–0.62) than among the children who received mega-dose capsules (RR = 0.59; 95% CI = 0.41–0.84). The risk of mortality at 2 years was reduced for both the nutrition education (RR = 0.64; 95% CI = 0.48–0.86) and capsule distribution (RR = 0.57; 95% CI = 0.42–0.77) cohorts. The nutrition education programme was, however, more expensive to deliver than the capsule distribution programme. High rates of participation for children in the supplementation programme were achieved quickly. The nutrition education messages also spread rapidly throughout the study population (regardless of intervention cohort assigment). Practices, however, were slower to change. In communities where maternal literacy was low and channels of communication were limited the capsule distribution programme appeared to be more economical. However, there are economies of scale for nationwide education programmes that do not exist for capsule distribution programmes. Although nutrition education provides economies of scale and the promise of long-term sustainability, a comprehensive national programme requires both dietary supplementation and nutrition education components.

Introduction

Historically, vitamin A deficiency (VAD) has occurred worldwide, but it now appears primarily to be present in certain developing countries.[a] The importance of vitamin A to the health and visual acuity of children has been known since the 1920s (*1*, *2*), but only in the last decade has it become clear that as many as 1–3 million deaths can be prevented through effective community VAD control programmes (*3*). Policy-makers in countries with VAD are now considering the most appropriate approaches to reduce and control this public health problem.

Traditionally, clinical xerophthalmia has been the primary indicator used to identify VAD; however, xerophthalmia is only the "tip of the iceberg" in

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this respect since sub-clinical VAD is associated with an increased risk of severe illness and mortality. Patterns of risk for VAD are generally extrapolated from studies of xerophthalmia and many factors influence the magnitude of this risk (*4*). Xerophthalmia, and hence VAD, is associated with poor immune function (*5*), increased risk of growth faltering, common childhood diseases, and higher risk for childhood mortality (*6*). Xerophthalmia also tends to cluster geographically. High levels of VAD occur in a limited geographical area such as districts and in specific villages; however, many villages in VAD-endemic areas have no xerophthalmia (*7*). Even within those few villages where there are children with xerophthalmia, the risk seems to be concentrated in specific neighbourhoods, involving children who have recently had an episode of measles, severe diarrhoea, or acute respiratory infection (*8*).

The following programmes have traditionally been used for the control of VAD: supplementation with high doses of vitamin A; fortification; horticulture; nutrition education; socioeconomic improvement; and public health activities (*9*). The semi-annual distribution of a mega-dose of vitamin A has been used successfully in several countries of south-east Asia, and is easy to implement, efficacious, and cost-effective (*10*). Dietary modification through nutrition education has also been proposed as the most appropriate way to control VAD. Promotion of the control of diseases commonly seen in children with xerophthalmia has also been proposed as the best way to improve their vitamin A status.

During discussions between the implementing agencies and donors on how to set up a national VAD control programme in Nepal, many alternatives were reviewed and each agency and organization proposed a slightly different solution. Several of the proposed pilot control activities were eventually selected for field testing.[b] The two activities reviewed here are vitamin A supplementation and nutrition education, which included horticultural and public health activity approaches.

Nutrition education has been promoted as the most appropriate way to improve the nutritional status of at-risk populations (*11*); however, it is often difficult to operationalize (*12*). Previous cost-effectiveness analyses of vitamin A deficiency control programmes have suggested that nutrition education only has a small effect on health status, unless programme resources such as personnel, equipment, and finances are large (*13*). Selective inexpensive elements of primary health care, such as deworming, promotion of oral rehydration therapy and immunizations, and making antibiotics available to village health workers for the control of acute respiratory infections (ARIs), were included with the nutrition education activities to improve their outreach and impact (*14*).

While cases of xerophthalmia had been seen at hospitals and clinics in Nepal, there was no information on the magnitude and distribution of risk for the condition prior to the national blindness survey carried out in 1980 (*15*). This survey found that the risk for xerophthalmia was focused in the lowland (Terai) areas near the border with India. While a risk for VAD has been observed in mountainous areas of Nepal (*16*), xerophthalmia appeared to be most prevalent in the Terai area (*17*).

The programme established two criteria for the comparison of the different activities: the cost (both as a project and extrapolated to different levels of programme intensity) and the impact of the programmes on health status, primarily xerophthalmia and wasting malnutrition. Additionally, to monitor the programme and to attribute its effect, coverage was also included as an evaluation criteria. Since the different approaches required time to achieve an impact on VAD, the project followed the populations covered by the different programmes for 24 months after implementation.

Materials and methods

The project was implemented in seven districts of Nepal in the Terai and mid-hill areas. Annual censuses were carried out on all households, collecting information on community and household factors that might be used in predicting risk. Physical and ocular examinations were performed on all the children aged under 10 years. The evaluation was completed in 1992 after three rounds of examinations.

Sample size

The primary study objective was to demonstrate alternative programme performance in improving vitamin A deficiency status. The indicators of programme performance that were used in sample size determination included presence of Bitot's spots (X1B) and the growth rates of the children during the study. Since the prevalence of clinical signs was low, large sample sizes were required to detect differences in the estimates of programme effects with adequate precision.

Determination of sample size was based on the expected prevalence of the number of Bitot's spots (X1B). The statistical power of the test was set at

[b] *Final report: Vitamin A Child Survival Project.* Ann Arbor, MI, University of Michigan, School of Public Health, 1993.

0.80 (type I rate = 0.05). The sample-size determination also considered the effect of clustered data collection on the precision of estimated rates. Each intervention group and the control group were estimated to require 13500 children aged 6 months to 10 years.

Selection of study subjects

The study design consisted of a two-stage area probability sample of 100 area units (clusters of wards, which resemble a rural village or community) in seven of Nepal's 75 districts. The seven districts chosen contained 457 subdistricts in 438 rural and 19 town locales. Care was taken to ensure that probability selection principles were observed and that each child in the seven districts would have the same chance of being included in the study (*18*).

The sampling unit was a block that incorporated a variable number of wards within a subdistrict, which was designed to include about 450 children below the age of 11 years. Each subdistrict had a probability of being selected proportional to its population size. A "treatment code" was then assigned systematically to each of the 100 selected subdistricts according to the geographical selection order. Maps of each district were consulted to ensure that subdistricts assigned to a particular treatment group were not contiguous. Using random tables and the reference number for each block in the subdistrict, we selected one block (or cluster of wards) from each subdistrict. A total of 75 of the 100 sites and 296 of the 395 wards were used in this analysis; these included sites that received the mega-dose vitamin A capsules (6–12-month-olds: 100000 IU; 1–10-year-olds: 200000 IU) the nutrition education cohort, and the control group.

Evaluation design

The programme impact evaluation design may be summarized as follows: all children covered in the initial cohorts received an intervention (the "control group" receiving treatment during examination only); after adjustment for systematic loss to the cohort, each child was weighted to represent an internal control and statistical analysis carried out as in a longitudinal experimental design; and odds ratio of risk between participants and nonparticipants at 12 months and 24 months after baseline assessment were compared, and subsequently also pre- and post-intervention rates of risk between cohorts.

Training

The evaluation staff, consisting of a team of administrators, enumerators, ophthalmic assistants, and anthropometrists, were trained before each of the examination cycles. The ophthalmic assistants spent a month in Bogor, Indonesia, where the Centre for Research and Development of Nutrition arranged an intensive training programme. The ophthalmic assistants underwent special training in the standardization of Bitot's spot recognition, and the team administrators, in site mapping. Training was given to the anthropometrists on the use of the equipment and standardization at each examination.

The village health workers (VHWs) and community health volunteers (CHVs) who delivered the control activities were trained at the district public health office. The health post staff received similar training and were responsible for managing the community health workers; refresher training was given annually. If programme monitoring identified a block with low coverage rates, supervision and additional training were given.

Field examinations

Five types of examinations were administered to the study children: ophthalmic, physical, anthropometric, blood, and faecal. The maps developed during the first year of the study with the household numbers were used to locate children and were updated at subsequent examinations. From the baseline data, listings of all household members surveyed by site were generated and used by the field teams in the second and third round of data collection to ensure high rates of follow-up examinations. If a child from a previous examination was reported to have died, a verbal autopsy was taken.

The examinations were administered using standard protocols provided by WHO and the U.N. The age of the child was calculated from the date of birth to the examination date using the Nepalese calendar and then converted to the Gregorian calendar. If birth information was not available, age was estimated using an events' calendar appropriate to the area of the study.

Data collection and data entry

Data collected by the field enumerators were coded in the questionnaire in the field. Forms were then organized by site and reviewed at the central field management office. Once finalized in the field, the data forms were sent to the central project office in Kathmandu for checking and data entry. Following each round of data entry, a series of data cleaning and editing procedures was performed to identify and correct any coding errors.

Costing methodology

To generate cost estimates of the inputs for each intervention, we recorded accounts of transfers and unit prices of physical resources and personnel. The categorization of cost elements is consistent with those used by the United States Agency for International Development (USAID) (*19*), with the exception that in the present study the accounting approach separated one-time costs into fixed and variable costs.

Costs were recorded separately for each intervention project. For each cost centre, cost elements were organized into the categories of programme development and testing, one-time initial investment expenditures, and recurring operating expenditures. The cost-recording methodology consisted of the following elements: collecting and reviewing reports on project expenditures and physical resources; developing unit prices from these reports; collecting and reviewing project reports from area supervisors on resource transfers; collecting reports on transfers of resources or money to health workers or health post staff; and reporting food expenditure information from surveys. Costs were then projected to determine the cost of setting up the different activities to cover an entire district.

Analysis

Four types of approaches were used in the analysis: a logistic regression analysis to predict areas of risk; a consideration of the rates of participation for the different activities within their respective cohorts, and how participation influenced health status outcomes; a determination of the relative risk for xerophthalmia, wasting, and mortality (*20–22*) by participation; and a cost-effectiveness analysis (*19*).

The logistic regression analysis was set up to identify those community, household and individual level risk factors that could best be used to predict risk for all three of the health status parameters. A total of 48 predictors (independent variables) were used that covered the following: community development; community agriculture; history of disease epidemics within the previous 3 years; economics of the ward; availability of government development projects; household wealth; household sanitation; degree of participation in the vitamin A child survival project; and the nutritional status of the children.

Community characteristics within each category were included in a logistic regression analysis, and the variable from each category with the strongest association with risk was included in a second-order regression for that indicator of health status.

All data management was carried out using dBase III+ and FoxPro versions 2, 2.5, and 2.6. Data analysis was performed on MS-DOS-based microcomputers, using SPSS-PC software (mainly version 6.01).

Results

Of the 296 wards included in this analysis, 44.9% did not have cases of Bitot's spots at baseline, and by the third year, 65.5% of the villages were free of Bitot's spots (Table 1). From the baseline measurement to the third year, the number of villages where the mean weight-for-height z-score was <-1 decreased from 67.2% to 55.4%. The number of villages where a death was reported among children in the preceding year also decreased from the second to the third examination.

The community factors identified by the logistic regression that could predict community (ward) level risk are summarized in Table 2 for Bitot's spots, wasting, and mortality, along with the project years during which they were important predictors.

Community risk for Bitot's spots was best predicted by community agricultural patterns and availability of foods in the market, household income and sanitation characteristics, and the average nutritional status of the ward. Increased community risk for Bitot's spots was associated with the production of millet and maize, while the production of pulses, sugar, and mango was associated with decreased risk. Villages that had a substantial number of men with income earned outside the household had a lower risk of Bitot's spots. Also, villages with markets had a significantly lower risk of Bitot's spots; however, large wards were at greater risk for xerophthalmia than small wards. High maternal literacy rates were associated with reduced risk of Bitot's spots, as was the presence of livestock. Poor household sanitation, as indicated by lack of latrines and poor drainage, also appeared to be a good predictor of increased risk. The factors in Table 2 account for 85% of the variation of ward level risk for Bitot's spots across sites in each of the 3 years of the study. The factors that account for community risk were remarkably consistent across all 3 years and did not appear to change after the implementation of VAD control activities.

As expected, none of the national vitamin A programme activities appeared to account for community risk for xerophthalmia at baseline. Maternal literacy (which the programme subsequently included as a nutrition education activity) was one of the dominant predictors of reduced community risk for Bitot's spots and wasting throughout the study.

Table 1: **Distribution of wards with no Bitot's spots, a mean weight-for-height *z*-score <−1.0, and no deaths at the baseline examination and the 12- and 24-month follow-up examinations**

	Number in:			
	Year 1	Year 2	Year 3	Significance
No Bitot's spots	133 (44.9)[a]	172 (58.1)	194 (65.5)	$P < 0.01$
Mean weight-for-height *z*-score <−1.0	199 (67.2)	166 (56.1)	164 (55.4)	$P < 0.05$
No dead children in preceding 12 months	—	130 (43.9)	157 (53.0)	NS[b]

[a] Figures in parentheses are percentages.
[b] Not significant.

The programme activities did, therefore, have an impact on the underlying patterns of community risk for xerophthalmia, but were not as important determinants of risk as other social factors. Even though the overall prevalence did decrease, many communities that were identified with a risk of Bitot's spots at baseline continued to be at risk throughout the subsequent two observations (although with lower levels of risk), despite the programme activities that took place.

Participation level

The programme played a more important role in reducing individual risk than in defining community risk. Participation was measured by reviewing coverage rates within the cohort that had been assigned to receive a particular intervention (Table 3).

A total of 75% of the children participated in the capsule distribution programme at 12 months and 80% at 24 months after the programme began. These rates are higher than normal in community health programmes in Nepal, because the monitoring activities (every 4 months) encouraged community health volunteers to be active.

Measurement of participation through nutrition education activities is more difficult than measuring participation in the capsule distribution programme. While the capsule distribution programme required mothers only to ensure that their children complied with occasional specific, short-term activities, nutrition education required more radical changes in behaviour, such as increasing the intake of vitamin-A-rich foods during the dry season, serving wild greens in areas not close to the jungle, as well as using specific primary health care activities. Mothers

Table 2: **Number of years that various social factors could be used to predict risk in the study wards[a]**

Factor	Bitot's spots	Wasting	Mortality
Availability of a market in the ward	1,2,3 (−)	—	—
Major agricultural product in the ward:			
Millet	1,2,3 (+)	1,2,3 (+)	—
Barley	—	1,2,3 (−)	—
Maize	1,2,3 (+)	1,3 (+)	—
Pulses	2,3 (−)	1,2,3 (−)	—
Sugar	1,2,3 (−)	—	—
Mangos	1,3 (−)	—	—
Oranges	—	—	—
Size of ward	1,3 (+)	—	—
Livestock	1,2,3 (−)	1,2 (−)	—
Maternal literacy rate	1,2,3 (−)	2,3 (−)	1,2 (−)
Some income generated outside household	1,2 (−)	1,2 (−)	—
Majority of ward low caste	—	1,3 (+)	—
Majority of ward farmers	—	1,2 (−)	—
Availability of latrine	1,2,3 (−)	—	—
Poor drainage in ward	1,2 (+)	—	—
Low rates of wasting in children	2,3 (−)	—	—

[a] (+) and (−) indicate whether the factor was associated with an increased or decreased risk, resp.

Table 3: **Participation in project activities at 12 months and 24 months, and the risk of Bitot's spots (X1B)**

	12 months:				24 months:			
		% Prevalence				% Prevalence		
Intervention cohort		Yes	No	95% Confidence interval		Yes	No	95% Confidence interval
Capsule								
% participation	75	—	—	—	80	—	—	—
X1B		0.3	0.67	0.45 (0.33 < RR < 0.60)[a]		0.23	0.39	0.59 (0.41 < RR < 0.84)[b]
Wasting		12.1	14.4	0.84 (0.80 < RR < 0.88)[a]		11.1	12.5	0.89 (0.85 < RR < 0.94)[a]
Knows DGLV best and cheapest[c]								
% participation	29	—	—	—	61	—	—	—
X1B		0.38	0.60	0.63 (0.42 < RR < 0.92)[d]		0.25	0.38	0.65 (0.48 < RR < 0.86)[b]
Wasting		11.08	13.52	0.82 (0.77 < RR < 0.88)[a]		13.13	15.27	0.86 (0.80 < RR < 0.93)[a]
Knows wild greens								
% participation	71	—	—	—	79	—	—	—
X1B		0.31	1.01	0.31 (0.23 < RR < 0.40)[a]		0.22	0.62	0.35 (0.24 < RR < 0.50)[a]
Wasting		11.24	18.58	0.61 (0.57 < RR < 0.64)[a]		10.82	16.13	0.67 (0.63 < RR < 0.71)[a]
Identify foods with vitamin A								
% participation	16	—	—	—	19	—	—	—
X1B		0.12	0.56	0.21 (0.08 < RR < 0.57)[a]		0.09	0.35	0.25 (0.10 < RR < 0.62)[b]
Wasting		9.52	13.80	0.69 (0.62 < RR < 0.77)[a]		11.74	12.02	0.98 (0.90 < RR < 1.06)[e]
Mother literate								
% participation	13	—	—	—	16	—	—	—
X1B		0.14	0.56	0.25 (0.11 < RR < 0.57)[a]		0.02	0.35	0.06 (0.01 < RR < 0.42)[a]
Wasting		10.88	13.73	0.79 (0.72 < RR < 0.87)[a]		9.89	12.28	0.80 (0.74 < RR < 0.88)[a]

[a] $P < 0.001$.
[b] $P < 0.01$.
[c] DGLV = dark green leafy vegetables.
[d] $P < 0.05$.
[e] Not significant.

sometimes complied, but often the information was not received or understood; also, some mothers understood the information but did not have the capacity to act on it. In other cases, the mothers might have received the information, but incorrectly understood it, while in other instances the VHWs/CHVs may have provided incorrect information. Mothers sometimes refused to pay attention to some information if it contradicted folklore.

After 12 months of programme activities, almost 97% of the mothers knew about vitamin A, including mothers in the capsule and control cohorts. As shown in Table 3, 71% of the mothers knew about wild greens after 12 months of the programme, but only 29% knew that dark green leafy vegetables were the best and cheapest source of vitamin A, and only 16% of the mothers could correctly identify foods that contained vitamin A.

After 24 months, the project was able to increase literacy rates through nonformal education of mothers in selected wards where rates of literacy were low. The overall maternal literacy rate at baseline was 6% and rose to 16% by the end of the study.

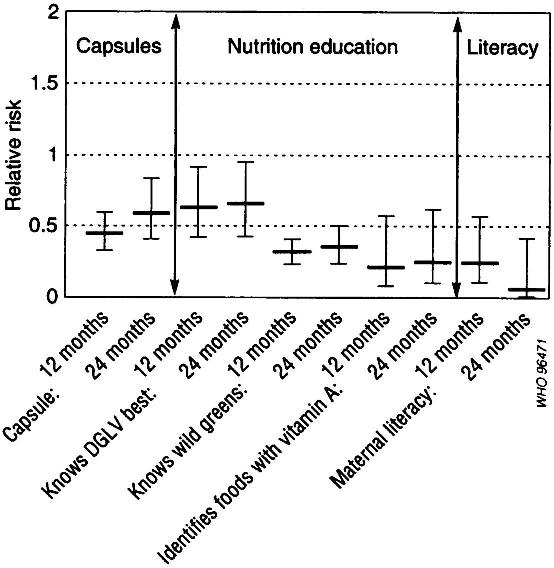
Although distribution of capsules could be restricted to the target population, it was difficult to keep the nutrition education messages from reaching both the capsule and control populations. It was rare to find a child who had received a capsule in the nutrition education or control cohort, but by the 24th month of activities, most mothers in all cohorts had heard about VAD and knew what caused it.

Risk of Bitot's spots

Participation in the capsule distribution programme reduced the risk for appearance of new Bitot's spots by 55%, corresponding to a relative risk (RR) of 0.45 at the 12-month assessment (Fig. 1); however, after 24 months, the capsules were not as effective in reducing the risk (overall RR = 0.59). At both the 12- and 24-month assessments, the reduction of risk was significant.

The impact of the nutrition education programme on risk for Bitot's spots appeared to vary according to the level of the mother's understanding of the messages. Incomplete understanding was associated with reduced risk, and more complete understanding with a very marked reduction of risk. Children whose mothers understood that dark green leafy vegetables are rich sources of vitamin A had an RR = 0.63–0.65 at both the 12-month and 24-month examinations. For mothers who understood that

Fig. 1. **Relative risk for Bitot's spots, by participation level in the project.** Bars show Taylor series 95% confidence intervals; if the upper bar is <1.0, the relative risk is significant.



wild greens were another good source of vitamin A, the RR was 0.31 at the 12-month and 0.35 at the 24-month examinations. If the mother was able to identify correctly from a list of foods those rich in vitamin A, the RR was 0.21 at the 12-month and 0.25 at the 24-month examination; and if the mother was literate, the RR for Bitot's spots was 0.25 at the 12-month and 0.06 at the 24-month examinations.

Wasting

Although the vitamin A capsule distribution activities were not associated with reduced community risk for wasting, they were associated with a reduced risk for those children who participated in the programme. To predict the community risk for high levels of wasting, many of the same variables employed to predict community risk of xerophthalmia can be used, the major difference being that cultivation of barley was not a sigificant risk factor for Bitot's spots, but was associated with risk of wasting at the ward level. Wards that were predominately low caste were also associated with increased risk for wasting, but not xerophthalmia.

As seen in Fig. 2, children who participated in the programme appeared to have a lower overall risk for wasting (i.e., weight-for-height <-2 z scores) than nonparticipants. Receipt of a vitamin A capsule was associated with a slight but significant reduction of risk of wasting at both the 12-month and 24-month examinations. In general, children who participated in the nutrition education programmes had an RR = 0.61–0.89 for wasting. The greatest reduction of risk for wasting was associated with knowing that wild greens are a good source of vitamin A.

Mortality

Table 4 shows the mortality risk for the specific intervention cohort in which the child was enrolled. At the 12-month examination, the risk of mortality (relative to that of the controls) was lower for both the capsule intervention (RR = 0.76) and the nutrition education cohorts (RR = 0.8); however, these reductions were not significant. By 24 months, the reductions in risk of mortality both for the capsule (RR = 0.57) and the nutrition education cohorts (RR = 0.64) were significantly different from that of the control group, but not from each other.

The mortality risk in the control group appeared to increase from the first to the second year of observation (82.7 deaths per 10000 population at 12 months to 89.8 per 10000 at 24 months). The association between reduced risk of mortality and the nutrition education and capsule distribution activities appeared to be higher during the second year of the

Fig. 2. **Relative risk for wasting, by participation level in the project.** Bars show Taylor series 95% confidence intervals; if the upper bar is <1.0, the relative risk is significant.

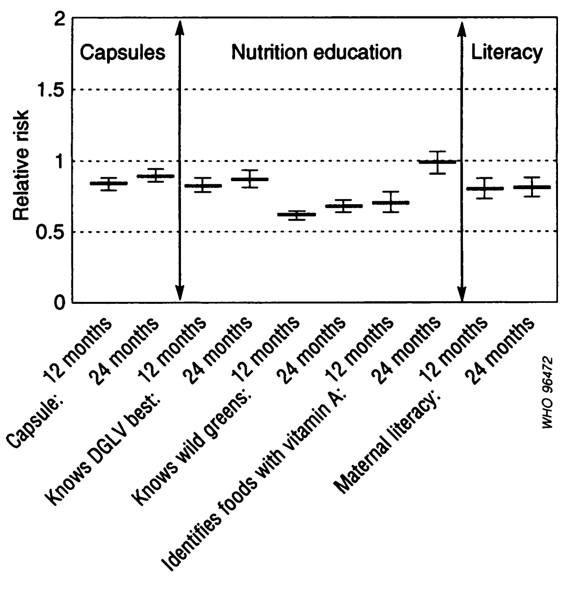


Table 4: **Mortality risk, by intervention cohort, at the 12-month and 24-month examinations**

Childhood mortality risk by:	12-month examination: No. of deaths	*n*	Death rate (per 10000)	95% Confidence interval	24-month examination: No. of deaths	*n*	Death rate (per 10000)	95% Confidence interval
Intervention cohort								
Control	106	12707	82.73	1.0	115	12702	89.72	1.0
Capsule	80	12594	63.12	0.76 (0.57 < RR < 1.02)[a]	63	12813	51.12	0.57 (0.42 < RR < 0.77)[b]
Nutrition education	90	13503	66.21	0.80 (0.60 < RR < 1.06)[a]	75	12963	57.52	0.64 (0.48 < RR < 0.86)[b]
Maternal attribute								
Literate	15	3598	41.69	0.56 (0.32 < RR < 0.97)[b]	9	4529	19.87	0.28 (0.14 < RR < 0.54)[c]
Non-literate	261	35206	74.14	1.0	244	33949	71.87	1.0
Knows foods with vitamin A	7	2692	26.0	0.35 (0.17 < RR < 0.74)[b]	16	4249	37.66	0.54 (0.3 < RR < 0.90)[b]
Doesn't know foods with vitamin A	269	36112	74.49	1.0	237	34229	69.24	1.0

[a] Not significant.
[b] $P < 0.01$.
[c] $P < 0.001$.

programme than the first. Most studies that have evaluated the impact of vitamin A supplementation on risk of mortality have reported a reduction in risk within 12 months (*23*). However, the present evaluation of a national programme indicated that it took longer than this to achieve a significant reduction in mortality risk.

Analysis of mortality risk in the absence of information on the participation of those who died has been called an "intent to treat" analysis (*24*). However, for nutrition education outcomes the characteristics of mothers whose children died are comparable to those of mothers whose children did not die. Table 4 shows that there were significant differences in the relative mortality risk of the children by maternal attribute. For example, the relative risk for children whose mothers knew which food had vitamin A compared with children whose mother did not know was 0.35 at 12 months and 0.54 at 24 months. The relative risk of mortality for children whose mothers were literate was 0.56 at 12 months, but fell to 0.28 at 24 months suggesting that such children were only a quarter as likely as children of nonliterate mothers to have died in their third year of life.

Cost of the programme

Table 5 shows the 5-year costs of covering a district with the capsule distribution programme; the nutrition education programme; and the nutrition education programme, including the maternal education programme. The cost of the various interventions increased threefold from the cheapest to the most expensive alternative.

The cost was low for all the approaches, especially the capsule distribution programme. Recurrent costs were higher for the nutrition education programme because the low literacy levels in the villages necessitated frequent delivery of resources. Nutrition education also required more supervision and travel time. The most expensive component of all was the adult literacy programme, which required teachers, books, and training materials.

Cost-effectiveness

A district-specific approach to cost-effectiveness analyses considered the cost and the impact of the alternative interventions tested in the programme. In an average district in southern Nepal of population 200 000, there are approximately 60 000 children under the age of 11 years. From May to September, 780 of these children will develop Bitot's spots; 540 will die each year; and 14 000 children will show signs of wasting.

The effects of the capsule programme and of the nutrition education programme on different parameters of health status over a 5-year period are shown

Table 5: **Five-year costs per district of the capsule distribution, nutrition education, and nutrition education programmes and the associated health status**[a]

	Capsules	Nutrition education	Nutrition education + literacy
Investment cost (US$ × 10³)	10	33	33
Operating cost (US$ × 10³)	15	45	64
Training(US$ × 10³)	2	11	11
Supplies (US$ × 10³)	10	29	29
Supervision (US$ × 10³)	2	5	5
Miscellaneous (US$ × 10³)	1	0	0
Adult literacy (US$ × 10³)	0	0	29
Total operating cost (US$ × 10³)	75	240	370
Total programme cost for 5 years (US$ × 10³)	85	273	403
Health status of district after 5 years			
No. of Bitot's spots prevented	2 535	2 340	3 510
No. of deaths prevented	1 160	1 085	1 600
No. of cases of wasting prevented	4 000	6 000	7 000
Cost per X1B prevented (US$)	33.53	110.26	114.81
Cost per death avoided (US$)	73.28	237.79	251.88
Cost per wasted child prevented (US$)	21.25	43.00	57.57

[a] Costs are in 1992 US$.

in Table 5. Additionally, the estimated cost of preventing a case of Bitot's spots, a death, or a wasted child is shown. For each of the measures of health status, the cheapest improvement in health status can be achieved by investment in the capsule distribution system.

Discussion

The analysis pointed to a consistent set of interconnected economic, ecological, and sociological problems that determine the level of risk of VAD, wasting, and excessive mortality in rural villages in Nepal. The interventions that were tested are effective in reducing risk among individual children, but none appears to affect strongly whether or not the community would continue to be a high-risk "cluster site". Attempts to prevent continued risk by improving economic opportunities, agricultural practices, and sanitary conditions are options, and undoubtedly as Nepal makes further economic progress, the risk of xerophthalmia will be further reduced among high-risk children. However, the activities used in the pilot programme (semiannual distribution of mega-dose capsules or increasing consumption of vegetables and selective primary health care activities) appear to be the primary policy options for the present.

The dilemma facing any health planner is, given limited financial resources, how to spend them. Our analysis has shown that a decision to implement a capsule distribution programme in Nepal might be more influenced by differences in the costs than by differences in the effects of programmes on health status and the relative costs over the long-term. The effect of the capsule distribution and nutrition education programmes on the health status measures of their respective cohorts were similar. However, the coverage rates for the capsule programme were much higher than those for the nutrition education programme.

The spectrum of health benefits associated with the control of VAD is dominated by the reduction in mortality. In the capsule cohort, the mortality risk was reduced only slightly more than that in the nutrition education cohort. It is also clear that specific components of the nutrition education and maternal literacy programme were more effective in reducing risk of morality than was the capsule distribution programme.

The advantages of the capsule distribution programme were its relatively low cost and the high rates of participation, which had a greater benefit–cost ratio than the nutrition education activities. The overall potential for improving health status is greater with nutrition education, but it requires additional resources.

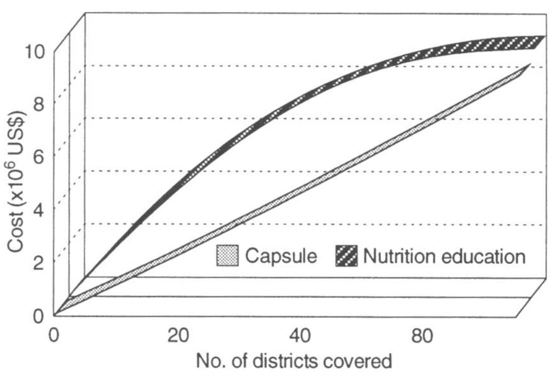
The decision to use a nutrition education or a mega-dose capsule programme might be influenced by several of the following factors:

- secondary spillover benefits to the communities, not measured by the evaluation, that might be used to justify the additional cost;
- "economies of scale" scaling up from a pilot district level project to a national project; and
- a combination of two approaches might create a more effective programme than a single intervention by itself.

In terms of spillover benefits, two factors that influence community risk (rather than individual risk) are maternal literacy and agricultural practices. The nutrition education programme can also affect cultivation practices and patterns, and the maternal literacy programme directly reduces one of the risk factors that predict xerophthalmia, wasting, or mortality risk in a village.

Fig. 3 shows that economies of scales can be generated in the nutrition education programme as it is enlarged to a national programme. For a nutrition programme, savings can be made by spreading the investment cost of materials development and the start-up cost over a larger group of people. As the nutrition education programme reached higher levels of coverage, the marginal cost of adding additional districts decreased. However, the cost of a national nutrition education programme exceeds that of a capsule distribution programme.

Fig. 3. **Comparison of the 5-year costs of the capsule distribution and nutrition education components of the project, by number of districts covered.**



Capsule distribution and nutrition education are not necessarily mutually exclusive activities and can be carried out successfully together; capsule distribution provides a useful point of contact with the mother for the community health worker, and nutrition education and promotion of maternal literacy will help reduce the roots of the problem. Although the difference between the most expensive and the cheapest intervention seems great, all of the approaches to control VAD are highly cost-effective. The most expensive VAD control programme can save a life at a cost of less than US$ 300 — very few public health activities, except immunization, are comparable in this respect.

Vitamin A programmes cannot be delivered in the absence of a basic health care delivery system. Similarly, dietary supplementation should not be carried out without also working on the root causes of the nutrition problems in rural communities. The risk for xerophthalmia is varied and, in areas of highest risk, it is probably necessary to use both capsules and nutrition education to have an impact on the prevalence of VAD.

Conclusion

The experience of VAD control programmes in Nepal demonstrates that nutrition education can be as effective as a capsule distribution programme. However, in areas such as Nepal, where the levels of literacy are low and the channels of communication limited, the cost of achieving the same level of effect was more expensive for the nutrition education than for the capsule distribution programme. In the past, policy-makers have been reluctant to use nutrition education programmes as the primary approach to the control of VAD, because such programmes have been held to be less effective than capsule distribution. In Nepal, nutrition education was less cost-effective than the capsule distribution programme, not because it was less effective, but because it was more expensive.

Nepal might be seen as one of the more challenging places to develop and implement a nutrition education VAD control programme. Few of the women are literate, there is a lack of prototype training materials, and there is substantial cultural and linguistic variation throughout the country. Nevertheless, an effective nutrition education programme was developed and implemented. In areas where most of the mothers are literate and there are multiple channels of communications, the cost of implementing an effective nutrition education programme should be even lower and the effect greater.

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Résumé

Impact de l'éducation nutritionnelle et de l'administration de doses massives de vitamine A sur la santé des enfants au Népal

La supplémentation alimentaire par distribution de capsules contenant une dose massive de vitamine A (6–12 mois: 100 000 UI; 1–5 ans: 200 000 UI) est souvent citée comme méthode de choix pour traiter rapidement la xérophtalmie et l'avitaminose A. L'éducation nutritionnelle visant à encourager la consommation accrue de légumes est plus souvent envisagée comme moyen à long terme de lutte contre cette carence. Alors que la plupart des décideurs paraissent reconnaître l'impact positif des modifications des connaissances et des pratiques nutritionnelles sur l'avitaminose A, les avantages de cette approche sont généralement considérés comme plus faibles ou moins accessibles que ceux d'un programme de distribution de capsules. La présente étude compare l'effet de ces deux approches sur la santé des enfants, et comporte une cohorte témoin positive. Les critères suivants ont été retenus: réduction du risque de xérophtalmie; amélioration de l'état nutritionnel chez les participants; réduction du risque de mortalité dans la cohorte; coût d'exécution du programme.

L'étude comportait un sondage aréolaire à deux degrés réalisé dans 100 services hospitaliers de sept districts appartenant à deux contextes écologiques distincts du Népal rural (Terai et collines de piémont), avec un effectif total d'environ 40 000 enfants. Elle était réalisée comme suit:

- Tous les enfants recrutés dans les cohortes initiales bénéficiaient d'une intervention (ceux de la cohorte témoin recevaient un traitement s'ils étaient malades au moment de l'examen).
- Après ajustement pour les enfants perdus de vue, chaque enfant était pesé pour obtenir une valeur de référence interne, et l'analyse statistique était effectuée comme pour une enquête longitudinale.
- L'impact du programme a été estimé par comparaison du risque relatif entre les participants et les non-participants au bout de 12 et 24 mois, et par comparaison ultérieure entre les taux de risque avant et après intervention dans les cohortes.

La réduction du risque d'apparition de taches de Bitot était plus importante chez les enfants dont la mère participait activement aux activités d'éducation nutritionnelle et de promotion de la santé que chez les enfants ayant reçu les capsules de vitamine A. De plus, les enfants ayant reçu les capsules à titre de traitement et ceux dont la mère avait participé aux activités susmentionnées avaient un risque plus faible de maigreur due à la malnutrition que ceux qui appartenaient à la cohorte de distribution de capsules ou ceux qui ne participaient pas à l'étude. Dans les deux cohortes de population, le risque de mortalité était abaissé. Le programme d'éducation nutritionnelle était toutefois plus coûteux que le programme de distribution de capsules en raison du coût élevé de la mise au point initiale de matériels éducatifs destinés à une population essentiellement illettrée. L'obtention de taux de participation élevés au programme de distribution de capsules a été relativement rapide. De même, les connaissances au sujet de l'avitaminose A ont été rapidement diffusées dans la population d'étude, quelle que soit la cohorte d'intervention, même si les pratiques ont été plus lentes à évoluer.

Il est possible de combattre rapidement l'avitaminose A avec le risque accru de mortalité et de troubles oculaires qu'elle entraîne, soit en recourant à la distribution de capsules contenant une dose massive de vitamine A, soit en informant les mères sur cette carence et sur les moyens d'y remédier. Ces deux approches peuvent avoir un impact significatif dans un laps de temps relativement bref. Cependant, dans les régions où le taux d'alphabétisation des mères est faible et où les possibilités de communication sont limitées, le programme de distribution de capsules semble plus économique. En revanche, il ne permet pas les économies d'échelle réalisables avec un programme d'éducation nutritionnelle mené au niveau national. Il ne faut pas considérer chaque approche comme suffisante en soi et elles doivent toutes deux être intégrées dans un programme national bien équilibré.

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