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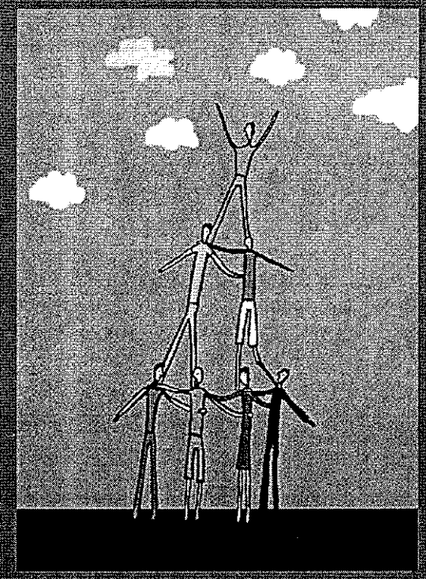
Nutrition and an Active Life



From Knowledge to Action

Wilma B. Freire, Editor

Pan American Health Organization
Regional Office of the World Health Organization

IMPROVING NUTRITION IN MEXICO: THE USE OF RESEARCH FOR DECISION-MAKING IN NUTRITION POLICIES AND PROGRAMS

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INTRODUCTION

The purpose of scientific research is to generate knowledge. The primary tool of research, in the various areas of knowledge, is scientific method, whose application enables the duplication of experiments or studies and the comparison of results in order to formulate plausible or likely statements regarding the relationships between the variables. Scientific method can be applied to the study of an assortment of issues, and its application may be motivated by human curiosity, without the findings of the research necessarily having an immediate practical application, or the purpose may be problem-solving or immediate practical application.

The National Institute of Public Health (INSP) of Mexico, an institution devoted to public health research and nutrition, has clearly defined its inclination towards generating knowledge in order to apply it to the improvement of the population's health. This type of research, termed "mission-based research" by Frenk (*1*), has been defined as "the development of a research effort that modifies some aspect of reality by producing knowledge and technology." The "mission" is precisely that modification of reality.

Mission-based research in public health therefore centers its efforts on improving the health conditions of the population by applying scientific method to the study of different objects and levels of analysis. The objects of analysis are the health conditions of the population and the organized social response (policies, programs, and actions) for the prevention and control of such conditions. The levels of analysis include subcellular particles (molecular biology), individuals (clinical research), populations (epidemiological research), and health systems (systems research), using a multidisciplinary approach to generate knowledge that makes it possible to resolve public health challenges. An important area of mission-based research is the use of scientific data for decision-making in public health, including the design and evaluation of health and nutrition policies.

An erroneous conclusion that is frequently drawn upon addressing the concept of mission-based research for the first time is that it deals with applied research, whose only purpose is problem-solving. A distinction is frequently drawn between applied research (often confused with mission-based research) and basic research, which generates universal knowledge. A key feature of the type of research that the INSP aspires to

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conduct is the attempt to generate fundamental knowledge; that is, research that has an effect on the conceptual structure or the perspective of a specific field of knowledge, and, at the same time, endeavors to be useful. This type of research, called "strategic" research, has been described by Stokes (2), who proposes that the traditional concept that standardizes research as a continuum in a single dimension, with pure research and applied research on either end, is inadequate. He also proposes that research should be conceived on a bidimensional plane, with one of its pillars represented by the search for the generation of fundamental knowledge and the other represented by the search for research usefulness. Strategic research is located in the quadrant that represents both the search for fundamental knowledge and its usefulness. A historical example of this type of research is the sort conducted by Pasteur, who combined both interests.

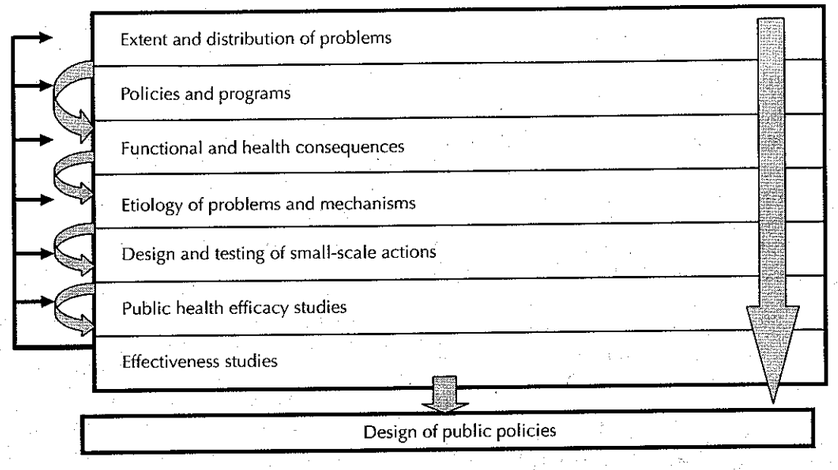
The Center for Research in Nutrition and Health (CINyS) of the INSP, in keeping with the philosophy of strategic mission-based research, seeks to develop a research agenda that aims to prevent and control poor nutrition in Mexico, through the generation of knowledge and technology intended to improve the effectiveness of the organized social response to the problems of poor nutrition. This chapter presents pieces of evidence on the use of scientific research findings in Mexico to generate actions aimed at preventing and controlling the population's poor nutrition and to design nutrition programs with a high potential for bringing about positive effects; data on the use of evaluations to fuel decision-making in existing programs and policies are also presented.

The CINyS, inspired by the philosophy of mission-based strategic research, has set up a format that serves as a guide for defining the Center's research agenda. Stages of mission-based research have been identified for each of the various problems related to poor nutrition or to the challenge faced by health systems in promoting adequate nutrition or preventing or controlling poor nutrition. These stages usually occur sequentially, but can also function iteratively; that is, upon reaching a higher stage it is sometimes necessary to return to a previous stage in order to answer the new research questions that have emerged.

The research sequence around the problems of poor nutrition (Figure 1) starts with (1) a study of the conditions (extent and distribution of the population's poor nutrition problems and their determinants) and responses (food, nutrition, and health policies and programs with a potential impact on poor nutrition), and continues with (2) studies on the functional consequences or on the health of the population suffering from poor nutrition, in order to determine the importance of the problems, followed by (3) studies on the etiology of the problems and on the biological or social mechanisms that explain them. The next stages consist of (4) the design and testing of small-scale actions or interventions, (5) controlled clinical trials for studying the efficacy of the interventions or actions, and (6) effectiveness studies or the evaluation of actions or programs, including process and cost-effectiveness evaluations. Figure 1 concludes with the design of policies and programs and their evaluation in order to provide feedback for the decision-making process. The results of the evaluation are useful for identifying operational or design problems, which leads to new research questions that, when answered, fuel the cycle of mission-based research at some point in the Figure. In this final process, there will be close interaction between the respective researchers and the civil servants who will be in charge of designing and managing nutrition and public health policies.

Reviewing the literature during the different stages is essential in order to identify the existing knowledge and the principal voids, as well as to determine the research needs; these are contrasted with the capabilities and comparative advantages of the CINyS in order to therefore define the lines of research and research projects to which the Center can

FIGURE 1. Stages of the mission-based research process.



contribute effectively. This process is useful for both determining CINyS' staff training and recruitment needs, and for forging strategic partnerships with other research groups in order to generate an effective critical mass that makes it possible to respond to the challenges of mission-based research.

The following is a chronicle of the way in which, through the application of this format, research findings have been used for designing policies and programs geared to the prevention of poor nutrition in Mexico. Several of the results that are useful in tackling malnutrition have also contributed to the fundamental knowledge in this field and have been published in Mexican and foreign peer review journals.

STUDIES ON THE EXTENT AND DISTRIBUTION OF NUTRITION PROBLEMS IN MEXICO (A STUDY OF THE CONDITIONS)

An important task undertaken by the CINyS has been conducting and analyzing probabilistic national surveys that show data on the nutritional status of the Mexican population and its determinants. In 1993, when the research group that would later become the CINyS was set up in the INSP, the data from the 1988 National Nutrition Survey (NNN), conducted by the Secretariat of Health (SSA) (3), were analyzed, disseminated, and published. Ten years later, the INSP sought financial support to carry out a second NNN. Support provided by the SSA and other organizations enabled the second NNN to be carried out between 1988 and 1999 (referred to in subsequent references as NNN-99). The surveys led to an understanding of the extent and distribution of the problems surrounding poor nutrition and the determining factors, and those data were disseminated both to the scientific community and authorities responsible for the formulation of food, nutrition, and health policies. As will be described in more detail further on, through the dissemination of publications and presentations targeted to key actors involved in the design and management of policies and programs, the results of the

NNN-99 set in motion various public actions, policies, and programs for preventing malnutrition.

The following is a brief summary of the NNN-99 findings, which constituted the basis for designing the resulting nutrition policies and programs, and represented significant input for defining the CINyS research agenda.

The leading problems resulting from poor nutrition in Mexico, according to the NNN-99, were linear growth retardation (short stature), anemia and deficiencies of several micronutrients, and overweight and obesity.

Linear Growth Retardation

In Mexico, short stature continues to be a significant public health problem among children under 5 years of age, while emaciation no longer constitutes a major problem at national and regional levels. Nationally, nearly one out of five children under 5 (17.7%) recorded low height in 1999, while only 2% showed emaciation. The analysis conducted on the prevalence of low height for this age group revealed that this phenomenon occurs predominantly during the first two years of life. Thus, while prevalence is 8% during the first year of life, it jumps to 22% during the second year, an increase of almost three times, and it remains at 20% up to age 4. There is not a subsequent recovery from short stature, as one can see upon studying the height of school-age children and women of childbearing age (4).

One of the most troubling findings of the NNN-99 was the inequity in terms of the distribution of malnutrition. Short stature is distributed heterogeneously among the population subgroups. Figure 2 shows the prevalence of short stature for each of the four regions studied,[2] by urban and rural areas and in indigenous children. Prevalence in rural areas (31.6%) is nearly three times higher than that of urban areas (11.6%), and in the north (the most prosperous region) it is much lower than in the south (the poorest region). A comparison between regions and urban and rural areas gives rise to greater differences. For example, while the prevalence in urban areas in the north is close to 6%, in the rural south it is more than 40%, almost seven times higher (5).

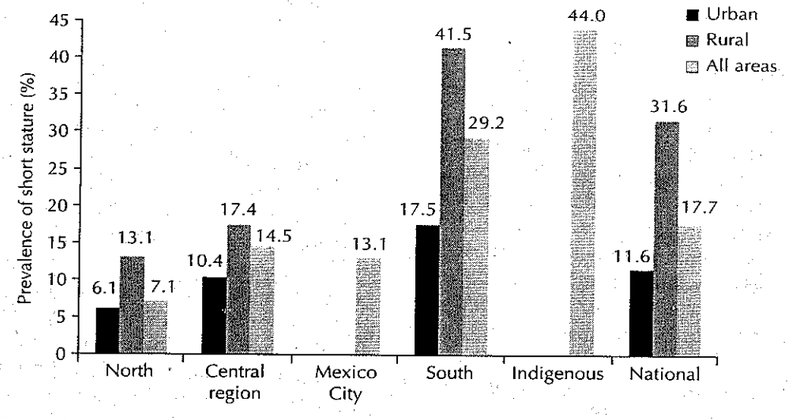
One of the groups with the poorest living conditions in Mexico is the indigenous population. Nearly two-thirds of the families with indigenous children under age 5 are located in the two lowest deciles for living conditions compared to less than 15% of the families with nonindigenous children. The prevalence of short stature is approximately three times greater in indigenous children (44.3%) compared to nonindigenous children (14.5%), and the differences are reduced to around half when adjusted for socioeconomic level, yet they continue to be significantly higher in indigenous children ($p < 0.05$) (6).

There is a strong tendency for the prevalence of short stature by decile of socioeconomic level to increase the lower the socioeconomic level is. The difference between the prevalence of short stature among the highest (4.6%) and lowest deciles (47.6%) was almost 10 times (5).

In 1988, the prevalence of short stature, low weight, and emaciation was 22.8%, 14.2%, and 6.0%, respectively. The changes recorded between surveys were 5.1 percentage points for short stature (22.4% with regard to the baseline), 6.6 percentage points for low weight (46.5% with regard to the baseline), and 4 percentage points for emaciation (66.6% with regard to the baseline). That is, there was a satisfactory reduction in the prevalence of emaciation, but the progress regarding short stature was less satisfactory, especially when compared to the decline recorded in South America as a whole during a similar period (5). The prevalence of short stature in South America dropped from 17.2% in 1990 to 9.3% in 2000;

[2]The NNN-99 was representative of four regions: the north, which mainly includes the bordering states of the United States; the south, which includes the poorest states; Mexico City, including the metropolitan area; and the central states.

FIGURE 2. Inequity in the distribution of poor nutrition (short stature) in Mexico.



Source: Rivera J, Sepúlveda-Amor J. Conclusions from the Mexican National Nutrition Survey 1999: translating results into nutrition policy. *Salud Pública Mex* 2003;45(Suppl 4):S565–S575.

that is, a decrease of 7.9 percentage points or 45.9% with regard to baseline prevalence (*7*). It has therefore been concluded that the decrease in prevalence of short stature recorded in Mexico from 1988 to 1999 is much lower than the one expected, particularly when taking into account significant government spending on food assistance programs during that period, which will be discussed in detail further on.

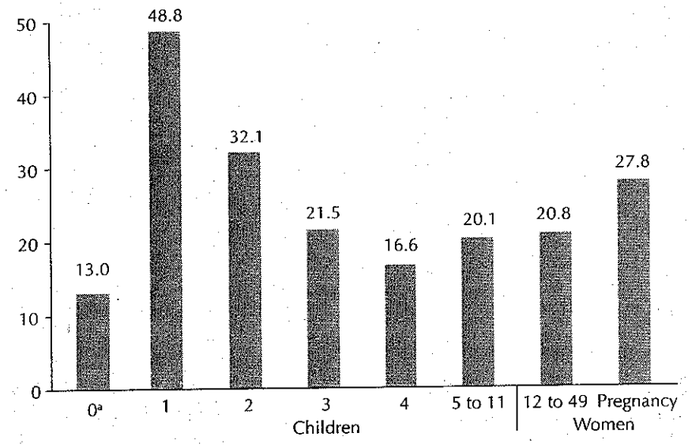
Anemia and Micronutrient Deficiencies

More than one out of four children under age 5 (27.2%) were anemic, and 25% to 50% of the children had deficiencies of one or more micronutrients (Figures 3 and 4). The prevalence of iron, zinc, and vitamin A deficiencies was 52%, 33%, and 27%, respectively. Furthermore, more than 25% of the children presented serum concentrations of ascorbic acid, which indicates a low daily intake of vitamin C from food (Figure 4).

Anemia and some micronutrient deficiencies appear predominantly at an early age. The prevalence of anemia reaches a peak in the second year of life, when it affects almost half of the children, and declines to nearly 17% at 4 years of age (Figure 3). Iron deficiency affects nearly two-thirds of all children ages 1 to 2 and less than 50% of children ages 3 to 4 (Figure 4). In contrast to short stature, the differences in the prevalence of anemia are not perceptibly different by region and between urban and rural areas, but are higher in indigenous children (35.8%) vis-à-vis nonindigenous children (26.1%) (*5, 6*).

The prevalence of anemia in children ages 5 to 11 was 20.1% (Figure 3), and the most prevalent micronutrient deficiencies in this age group were iron (36%), vitamin C (30%), vitamin A and zinc (around 20%), and folic acid (nearly 10%) (Figure 4) (*8–10*). The national prevalence of anemia was 20.8% in non-pregnant women and 27.8% in pregnant women (Figure 3) (*11*), and the micronutrients with the highest prevalence of deficiency in non-pregnant women were iron (40.5%) and vitamin C (39.3%), followed by zinc (25.3%), while deficiencies in vitamin A and folic acid were around 5% (Figure 4) (*9, 10*).

FIGURE 3. Prevalence (%) of anemia in children and women, Mexico, 1999.



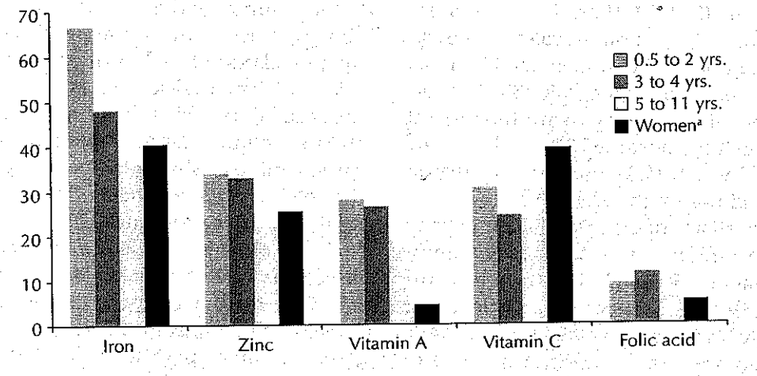
[a]6 to 11 months.

Source: Rivera J, Sepúlveda-Amor J. Conclusions from the Mexican National Nutrition Survey 1999: translating results into nutrition policy. *Salud Pública Mex* 2003;45(Suppl 4):S565–S575.

Overweight and Obesity

Overweight and obesity have become a national epidemic in Mexico, particularly in adults, and already represent a concern in children. The national prevalence of overweight (z-score of weight-for-height > +2) in children under 5 is 5.3% (Figure 5) with greater percentages in the north (7.2%), compared with the other regions (4% and 5%), and in urban areas (5.9%) vis-à-vis rural ones (4.6%). The prevalence in 1988 was 4.2% (Figure 5); as a result, the increase over 11 years was 1.1 percentage points (4).

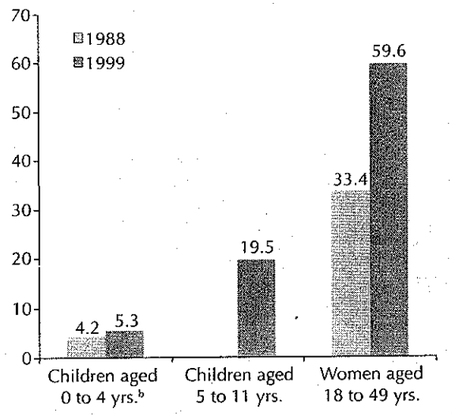
FIGURE 4. Prevalence (%) of deficiency of selected micronutrients, Mexico, 1999.



[a]Not pregnant.

Source: Rivera J, Sepúlveda-Amor J. Conclusions from the Mexican National Nutrition Survey 1999: translating results into nutrition policy. *Salud Pública Mex* 2003;45(Suppl 4):S565–S575.

FIGURE 5. Prevalence (%) of overweight and obesity in children[a] and women in Mexico, according to results of 1988 and 1999 surveys.



[a]In 1988, children aged 5 to 11 years were not studied.
[b]z-score of weight-for-height > +2.
Source: Rivera J, Sepúlveda-Amor J. Conclusions from the Mexican National Nutrition Survey 1999: translating results into nutrition policy. *Salud Pública Mex* 2003;45(Suppl 4):S565–S575.

The combination prevalence of overweight and obesity (*12*) in children ages 5 to 11 is 19.5% (*13*) (Figure 5). The regions with the highest prevalence were Mexico City (26.6%) and the north (25.6%), followed by the central region (18.0%) and the south (14.3%). The prevalence was much higher in urban areas (22.9%) than in rural areas (11.7%). The combination prevalence of overweight and obesity in women aged 18 to 49 (Figure 5) was 59.6% nationally (35.2% overweight and 24.4% obesity), with the highest prevalence in the north (65.3%), followed by Mexico City (59.1%), the central region (58.6%), and the south (55.3%).

The prevalence of overweight and obesity in women underwent an unusually significant increase over the 11 years between surveys. In 1988, the national prevalence of overweight and obesity was 24.0% and 9.4%, respectively (Figure 5), with an increase of 11.2 percentage points for overweight (an increase of 46.7% with respect to the baseline) and 15 percentage points for obesity (an increase of 160% with regard to the baseline) (*14*). The examples shown for using research for policy and program design and decision-making refer to problems pertaining to malnutrition and not to overweight and obesity.

STUDIES ON THE ORGANIZED SOCIAL RESPONSE: NUTRITION POLICIES AND PROGRAMS IN MEXICO

Mexico has a long history of carrying out policies and programs aimed at improving the nutrition of vulnerable groups. Despite this, malnutrition continues to be one of the country's most important public health challenges. Several CINyS publications analyze, from a historical perspective, the main strategies, programs, and policies that have been implemented in Mexico, by examining their design and implementation, as well as some of the results obtained (*15*, *16*). Through these analyses, it becomes evident that the country has made considerable investments in food assistance programs. For example, in 1993 the Mexican Government spent more than US$ 2 million a day on food assistance programs, including consumption subsidy programs. This figure is greater than the minimum food assistance expenditure recommended by various organizations in order to improve the population's nutrition. However, as shown in the previous section, the prevalence of malnutrition, anemia, and micronutrient deficiencies is elevated, and the speed of reducing the prevalence of short stature, an indicator of chronic malnutrition, turned out to be slower than expected during the 1990s, despite sizeable investments in food assistance programs.

These observations led to an examination of various aspects of the food assistance provided by the Government in 1988, in accordance with data from the survey conducted that year, including the extent and distribution of this assistance, in comparison with the nutritional needs of the population. That research produced very valuable findings

that were used by the CINyS to influence the design of nutrition policies during the 1990s.

It was concluded that among the reasons explaining the low effectiveness of nutrition programs in Mexico was the fact that they were not targeted to the population groups that needed them the most. Figure 6 illustrates the distribution of short stature children in 1988 and the percentage of beneficiary families of the various food assistance programs by region. Of the almost 2 million children with short stature, nearly 45% were in the southern region of the country, the poorest one, while less than 9% of the children with chronic malnutrition were located in Mexico City. Yet 51% of the families with children under age 5 benefiting from food assistance resided in Mexico City, and only 15% lived in the south, the region with the highest rates of prevalence (Figure 6).

It was also found that the probability of receiving food assistance (Figure 7) was 0.47 for families in rural areas vis-à-vis those in urban areas (using as a reference a probability of 1 for the latter), 0.24 for indigenous families vis-à-vis nonindigenous families, 0.42 for the tercile with low living conditions vis-à-vis the tercile with high living conditions, 0.87 for families with children under age 2 vis-à-vis families with children ages 2 to 4, and 0.65 for families with short stature children vis-à-vis families without short stature children (Figure 7) (17).

Apart from the emphasis placed on urban areas and the lack of targeting regions with the highest prevalence of malnutrition, it was found that among poor families, indigenous groups, and children under age 2, distributed or subsidized food was not adequate for feeding children ages 6 to 24 months; there was no coordination between the programs, which led to the duplication of efforts and benefits; and the educational component was weak. These results were very useful in modifying the bases of the nutrition policies and programs at the end of the 1990s, as will be seen further on.

STUDIES ON THE FUNCTIONAL CONSEQUENCES OF THE PROBLEMS OF POOR NUTRITION ON THE POPULATION'S HEALTH

The CINyS has collaborated closely with the Institute of Nutrition of Central America

FIGURE 6. Distribution of children with short stature and from beneficiary populations of food assistance programs, by region, 1988.

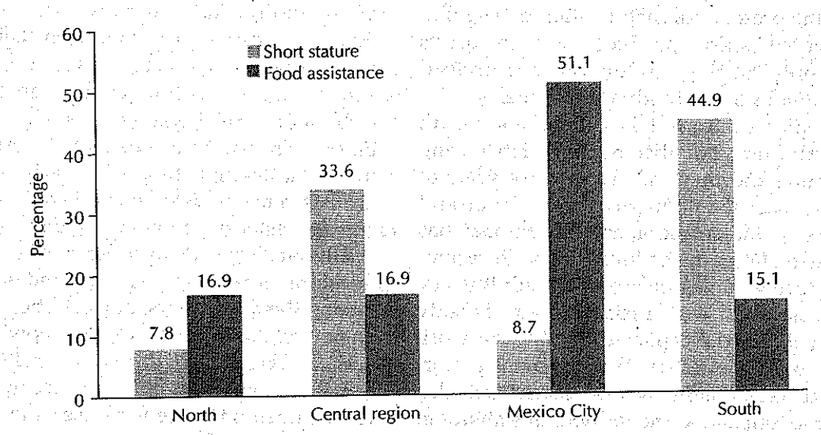
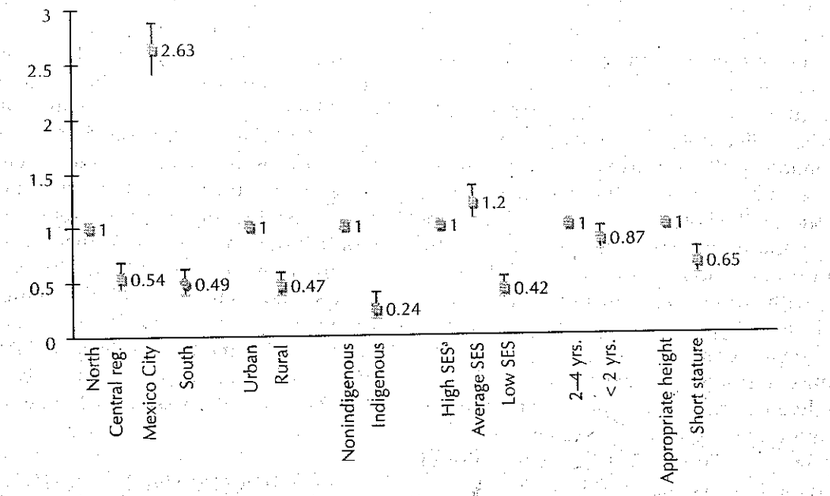


FIGURE 7. Rate of probability (95% CI) of participation in food assistance programs of households with children under 5.



[a]Socioeconomic status.

and Panama (INCAP) and with Dr. Reynaldo Martorell and his group of researchers, currently at Emory University. Within the framework of this collaboration, CINyS researchers have participated in various analyses on the functional effects of malnutrition during gestation and the first years of life (the formative period), which have shown that the presence of malnutrition during that formative period produces adverse effects not only during childhood but indeed throughout the individual's lifetime.

Studies conducted in collaboration with INCAP point out that malnutrition during gestation and the first two or three years of life is associated with growth retardation and psychomotor development (*18*, *19*) and has adverse effects in the longer run. For example, during adolescence and the adult years, it is associated with a reduction of: (1) body size (*20*), (2) the capacity for physical work (*21*), and (3) intellectual and school performance (*22*). These factors clearly can also have an impact on the individual's ability to generate income (*23*).

The studies furthermore demonstrate that malnutrition during the first years of life has effects on reproductive variables. For example, women with a history of moderate malnutrition during childhood have children with lower birthweights than women who were better nourished during that period of life (*24*). Low birthweight increases the risk of morbidity and mortality, which means that the nutrition of girls during their early developmental years can affect the health and survival of the following generation.

In short, collaborative research with the Emory University group and INCAP illustrates that malnutrition in the early stages of life not only depletes one's health and decreases chances for survival during childhood, but also leads to adverse effects on the development of human capital and on health during the adult years, and additionally has an impact on the health of the following generation. These data, by showing the functional consequences of the problems related to malnutrition, were very useful in providing a context for the problems prevalent

in Mexico and thus in convincing decision-making authorities of the need for applying actions geared toward preventing malnutrition.

STUDIES ON THE ETIOLOGY OF THE PROBLEMS AND THE BIOLOGICAL OR SOCIAL MECHANISMS THAT EXPLAIN THEM

Once the main problems of malnutrition in the population and their importance have been determined, as well as the problems the CINyS has the capacity and comparative advantages to address, it is possible to identify the priority problems for research purposes. Then it becomes necessary to garner information on the etiology and the biological and social mechanisms that explain the epidemiology of the problem in order to undertake preventive or corrective actions. It is critical to review the literature at this stage for the purpose of identifying any possible gaps in the knowledge that need to be addressed through research, taking into account capacities and comparative advantages.

Following is a brief description of some of the contributions made by the CINyS during this stage of knowledge generation that have been useful for decision-making in public health.

Studies conducted in collaboration with INCAP have shown that zinc supplementation in children with zinc-deficient diets has positive effects on growth (*25*), on reducing bouts of diarrhea (*26*), and on increasing physical activity (*27*). This finding illustrated the need for including zinc in interventions in order to prevent stunting.

CINyS researchers have also conducted studies on the bioavailability of different chemical forms of iron and zinc in various fortified foods, with a view to designing or modifying strategies for preventing both iron and zinc deficiencies, both of which constitute major public nutrition concerns in Mexico.

One of the studies showed that reduced iron, added to a food supplement designed to lessen anemia and iron deficiency, had very low bioavailability, while two more forms of ferrous iron—sulfate and fumerate—had high bioavailability (*28*). These results have been used by the CINyS to recommend substituting the type of iron added to supplements.

Another study indicated that the absorption of zinc oxide—a chemical form of low-cost zinc that is currently being used in several fortified foods distributed by various programs—is similar to the more expensive zinc sulfate, when added to a corn flour-based food supplement. This led to corroborating the fact that the type of zinc used in food fortification programs in Mexico is adequate (*29*).

Recent research quantified the amount of iron absorbed by adding two forms of "marked" iron (Fe57 and Fe58) to milk. The absorption of iron contained in milk corresponded to 10% of the total quantity of iron added. This absorption value makes it possible to calculate the quantity of iron assimilated with regard to milk consumed. Thus, a child who consumes the 400 mL of fortified milk recommended by the program will be absorbing, with the milk, 50% to 150% of the amount required to meet his/her needs for iron, depending on the child's age.

Another relevant finding was obtained from an analysis of a Guatemala study conducted by INCAP (*30*), which demonstrated that the effects of food supplementation on the growth of children at risk of malnutrition are elevated during the first two years of life and following that are almost null. For example, the size gain from 100 kcal of food supplement is almost 1 cm during the first year of life, approximately 0.5 mm during the second year, and 0.4 mm during the third year, while the figure ranges from 0 to 1.5 mm per year for children ages 3 to 7. This finding has been used to argue in favor of strengthening the recommendation to give priority to interventions targeted at the early stages of life.

DESIGNING AND TESTING SMALL-SCALE ACTIONS OR INTERVENTIONS

The CINyS has designed actions or strategies aimed at improving the population's nutrition and has tested them on a small scale in order to evaluate their feasibility and effects. Two examples will be briefly described here.

As a part of designing fortified food supplements, the CINyS has conducted several studies of acceptance and consumption at the community level (*31*). Furthermore, small-scaled strategies of educational communication have been developed and evaluated in order to improve the consumption of a nourishing supplement distributed as part of a national program (*32*).

Before providing examples of efficacy and effectiveness studies, some examples of the use of scientific research findings to influence decision-making for nutrition policies and programs are presented in the following section.

USE OF RESEARCH FINDINGS TO MOTIVATE PUBLIC NUTRITION ACTIONS

The CINyS has used research findings to promote among decision-makers the design and application of policies and actions geared toward improving the nutrition of the population. This section will describe some of the policies and programs whose initial motivation was the dissemination of research results directed at those responsible for health and nutrition policies, or whose design fed off of that information.

In the mid-1990s, the Mexican Government began planning an ambitious program for investing in human development in which the Secretariats of Finance, Education, Health, and Social Development participated. This program, initially called the Program for Education, Health, and Food (Progresa) and currently called Oportunidades, is a federal poverty-fighting initiative that targets low income families and their children's health, food, and educational needs and dispenses monetary transfers as incentive for encouraging the development of human capital. The participating families only receive the money if they regularly visit their local health facilities, receive health education, and enroll their children in school and ensure their regular attendance. Oportunidades began in 1997 as a national program developed to cover the immediate needs of Mexico's lowest income families and to break the intergenerational transmission of poverty. At present, it serves approximately 5 million families in rural and urban areas, selected on the basis of their low socioeconomic level.

The group in charge of designing the program consulted the INSP concerning the potential effect of the project—as originally proposed—on the nutritional status of children. The parties involved presented and extensively discussed the various pieces of evidence suggesting that gestation and the first years of life constitute a fundamental formative period and offer a unique window of opportunity to apply effective actions aimed at improving nutrition. Also shown were results of studies that underscore the importance of including micronutrients, especially iron and zinc, in assistance programs to combat malnutrition. Proof was also provided that the majority of the problems associated with malnutrition (short stature, anemia, and deficiencies of some micronutrients) show higher prevalence rates in the poorer population: in the southern region, among rural populations and indigenous families, and among those who belong to the lowest rungs on the socioeconomic ladder (*3*). This finding supported one of the pillars of the program; i.e., focusing actions on low income families. In addition, data were provided on the inadequate design and orientation of food assistance programs in Mexico, as described earlier in this chapter.

CINyS researchers, when consulted by those responsible for designing the Progresa program, expressed their concerns regarding a basic assumption by the program designers that ensuring monetary transfers to low income families would be sufficient to improve the population's nutrition. The researchers particularly expressed reservations about whether the monetary transfers would substantially improve the food and nutrition status of mothers and children during the vulnerable period of gestation up until the third year of life. CINyS staff submitted evidence obtained from the Mexican population on the inadequate practices of child feeding during the critical period of the first two years of life, during which time foods rich in several nutrients had been excluded, and they showed that these types of practices are considerably influenced by cultural and social factors, in addition to economic factors, and that of these, only the latter (economic) factors would be affected by the receipt of money transfers. Furthermore, the CINyS recommended adding a component that included the distribution of highly nutritional supplements in order to support nutrition during the formative stage, in conjunction with effective nutrition education activities that ensure adequate use of the supplements and utilization of the additional income for purchasing highly nutritional foods.

The CINyS researchers also proposed creating an Expert Committee on Nutrition (CEN) comprised of various institutions devoted to research in this field. CINyS recommendations were approved, and the CEN received a mandate from the Mexican Secretariat of Health to develop the nutrition component of the program, which included the distribution of micronutrient-fortified foods to children ages 4–23 months, to low-weight children ages 2 to 4, and to lactating and pregnant women. The CEN was responsible for designing the fortified foods based on existing knowledge of the nutritional status of the population (*3*, *33*, *34*). The supplements were therefore specifically designed for young children and women. The ingredients used in their preparation were powdered whole milk, sugar, maltodextrins, vitamins, minerals, and flavorings, and contained the nutrients that are most deficient in Mexican children's diets (Table 1) (*35*). Children under age 2 and lactating and pregnant women from low income families made up the target group of these nutrition actions. The program also included an evaluation component as an essential part of its design (*31*).

In addition to Oportunidades, other nutrition programs have also been designed or adapted as a result of having disseminated the research findings to those responsible for shaping public policies. One of them is a large-scale program of pharmacological supplementation with multiple micronutrients, whose purpose is to prevent anemia and micronutrient deficiencies in infants in predominantly indigenous communities that have the highest prevalence of malnutrition nationwide (*6*). Inputs for program design were the results of the NNN-99 and a study on the efficacy of micronutrient supplementation, to be discussed in this chapter's following section.

Another example is a subsidized milk distribution program in operation over the last 30 years (*16*) and recently modified on the basis of NNN-99 findings. The program cur-

TABLE 1. Content of calories and key nutrients in fortified foods distributed to children by the Oportunidades program.

Nutrient	DRI[a] (%)
Calories	15
Protein	36
Iron	100
Zinc	100
Vitamin A	100
Vitamin E	100
Vitamin C	100
Folic acid	100
Vitamin B12	100

[a]Daily recommended intake (DRI) for children aged 1 to 3 years.

rently focuses on the importance of addressing iron and zinc deficiencies by fortifying milk with iron, zinc, vitamin C, and other micronutrients lacking in Mexican children's diets. This milk is currently distributed to some 5 million children ages 1 to 12. Evaluation of the efficacy and effectiveness of the milk fortification program is now underway.

The ultimate purpose of the NNN-99 was the application of its results to improving the nutritional and health status of the Mexican population. Accordingly, the INSP devoted considerable efforts to the dissemination of the survey's results, which were published at the end of 2001 (*4*). Following this, there was an intensive period of more than 100 presentations given to key individuals in charge of designing and implementing food, nutrition, and health policies and programs; to the academic community interested in the topic (including students); to the private sector; to lawmakers; and to the media, which concluded with the publication of a series of articles targeted to the scientific community (*5, 6, 8–11, 13, 36–39*). One of the first presentations of NNN-99 results was given in January 2002 to the Secretary of Health and his principal advisors. As a result of that presentation and subsequent follow-up meetings, various initiatives were born that have had a direct impact on the decisions pertaining to the nutrition policies and programs put into practice by the health sector.

In the discussion following the presentation, the Secretary of Health remarked on the importance the survey results would represent for the Secretariat of Social Development (SEDESOL), in view of the fact that this ministerial entity is in charge of overseeing the country's poverty reduction programs, several of which include food distribution components. He pledged to arrange a meeting with SEDESOL, which was subsequently held in February 2002. At that meeting, SEDESOL learned of the survey results, showed great interest in contributing to efforts to reduce the prevalence of malnutrition, and signaled its desire to initiate actions in the short term. Among the concrete actions recommended by INSP researchers so that SEDESOL might effectively contribute to reducing malnutrition were changes to the Community Milk Supply Program (*Programa de abasto social de leche*) entrusted to the Liconsa company. The program had extremely high coverage (around 4.6 million children at the time of the SSA-SEDESOL meeting), distributed an excellent quality of milk, enjoyed a large degree of acceptance by the population, and could serve as a vehicle for Mexican children to receive various nutrients lacking in their diet if these nutrients could be added without affecting the milk's overall quality or its acceptance by the beneficiaries. Iron, zinc, and several vitamins were highlighted as possible nutrients that could be added to the milk.

The Secretary of SEDESOL showed a great deal of enthusiasm regarding these ideas and instructed Liconsa's director-general to meet as soon as possible with CINyS researchers in order to evaluate the feasibility of adding micronutrients to the company's milk supply and of setting up a team to design a milk fortification project. The work carried out by the team involved researchers from the INSP and other national and foreign institutions, as well as Liconsa technical and administrative personnel. The team's efforts led to the development of a micronutrient-fortified milk distribution program that was officially launched in August 2002, just six months after the initial meeting with SEDESOL.

The INSP recommended evaluating the program's impact on the nutritional status of the beneficiary children and proposed that SEDESOL focus both on its efficacy; i.e., the effects of the program under controlled conditions that would ensure consumption, as well as its effectiveness; i.e., the effect of the program in its day-to-day operations.

The following section describes the preliminary results of the evaluation of the efficacy of the fortified milk distribution program.

CONTROLLED CLINICAL TRIALS FOR THE STUDY ON THE EFFICACY OF THE INTERVENTIONS OR ACTIONS

Before implementing large-scale programs, it is advantageous to have scientific data on the efficacy of the programs or actions; that is to say, on the effects of the intervention when it is carried out under ideal conditions.

Two examples of efficacy studies are presented. The first refers to a test on the effects of supplementation with multiple micronutrients on linear growth that served as the basis for the design of a micronutrient supplementation program geared toward the country's indigenous population, which has the highest prevalence of malnutrition. The second is a study on the efficacy of fortified milk on the prevalence of anemia and the status of iron and zinc in children under age 2.

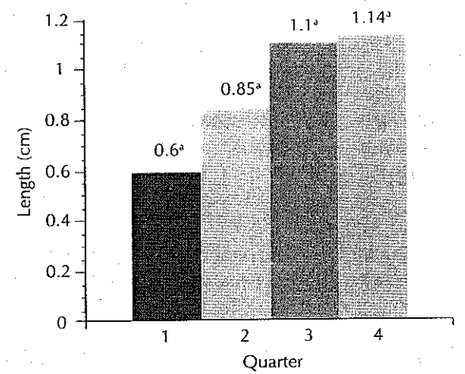
The study on the effects of supplementation with multiple micronutrients, a randomized, double-blinded clinical trial (*40*), showed that one of the causes of growth retardation in Mexican children is micronutrient deficiency. Moreover, it showed that the effect of supplementation with multiple micronutrients was restricted to children less than 12 months old. Children less than 12 months old who received the micronutrient supplement grew an average of 1.14 cm more than the children who did not receive the supplement during the first year of life (Figure 8).

The objective of the study on the efficacy of fortified milk was to determine the effect of this product, under ideal conditions, on the prevalence of anemia, and iron and other micronutrient deficiencies (*41*). Preliminary results are presented exclusively as to the effect on anemia.

One hundred eighty children 12 to 30 months old upon beginning the study were selected. One group of children received two glasses of fortified milk daily and the other group received unfortified milk for 12 months. The milk was delivered to the homes of the study subjects, and research personnel confirmed that the children consumed the quantity of assigned milk. Before beginning the supplementation, and six and 12 months later, height, weight, and blood samples were taken. Blood samples were measured to determine the concentration of hemoglobin that makes it possible to quantify the prevalence of anemia, while weight and height data were used to assess growth.

Preliminary results indicated that among the children who were 12 to 23 months old at the beginning of the study, at six months the prevalence of anemia among those who consumed fortified milk decreased by almost twice as much (26.3 percentage points) as it did in the children who consumed unfortified milk (13.7 percentage points); as for the children 24 to 30 months old, the reduction for those who consumed fortified milk was

FIGURE 8. Effects of micronutrient supplementation on growth of children under 12 months, during the initial stage, by quarter of supplementation.



[a]$p < 0.05$.

Note: Generalized Estimation Equation (GEE) adjusted on the basis of initial size, initial age, sex, breast-feeding, and socioeconomic conditions.

Source: Rivera JA, González-Cossío T, Flores M, Romero M, Rivera M, Téllez-Rojo MM et al. Multiple micronutrient supplementation increases the growth of Mexican infants. *Am J Clin Nutr* 2001;74(5):657–663.

around 50% greater (14.5 percentage points) than it was for those who consumed unfortified milk (9.5 percentage points). The results indicate that fortified milk is highly effective in reducing the prevalence of anemia.

The study on the effectiveness of fortified milk on the nutritional status of the beneficiaries has only more recently been concluded, and the results will be analyzed and published shortly.

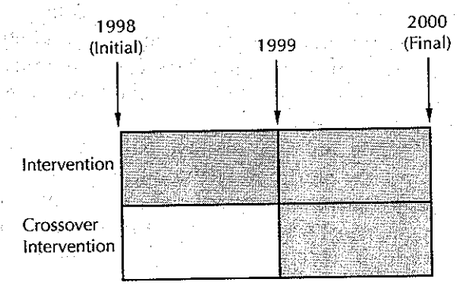
EVALUATION OF STUDIES ON THE EFFECTIVENESS OF ACTIONS AND PROGRAMS

Since the end of the 1990s, Mexico has undergone a fundamental change that has led to a culture of public policy and program evaluations. The change began with the Oportunidades program, whose first director insisted on including an evaluation component in the program design. This culture of evaluation has continued, and today the majority of the policies and programs of the Secretariat of Health and of SEDESOL are subject to evaluation.

The information presented here relates to the evaluation of the effectiveness of the Oportunidades program on the nutritional status of the beneficiary children (42), taking into account the nature of the program and the benefits it provides to the target population, as were described earlier in this chapter. Those benefits include the distribution of a micronutrient-fortified food supplement that is designed specifically to correct the nutritional deficiencies of children aged 4 to 23 months old and low-weight children ages 2 to 4 years of the families included in the program.

The program initially included some 300,000 households. Since it was not possible to provide immediate coverage to its target population (around 4.5 million families), the evaluation study was originally planned with a randomized design in which a group of localities was assigned at random to one of two groups: the first group would receive the program benefits for two years, while the second group would receive the benefits only after the two years of the study were complete. In practice, the design of the study remained intact during the first year (1998–1999); that is, while one group received the benefits of the study, the second group was kept as a control and did not receive any benefits. However, during the 1999–2000 period, both groups received the program benefits. This explains why the group that received the program benefits for two years was called the intervention group, and the group that received the benefits only during the second year was called the crossover intervention group, since it began as a control but "crossed over" to become an intervention group during the second year. Although it would have been desirable to preserve the original design, it was not possible. Nonetheless, with this design it was still possible to evaluate the effect of the program, since the intervention group received the program benefits for two years, while the crossover intervention group received them for only half of this period. Furthermore, the intervention group received the program benefits during the critical period of the first two years of life, while the crossover intervention group did not receive them for much of that period (Figure 9). The greatest impact was to be expected in the children less than 6 months old in 1998, since those who be-

FIGURE 9. Design of effectiveness evaluation of the Oportunidades program.

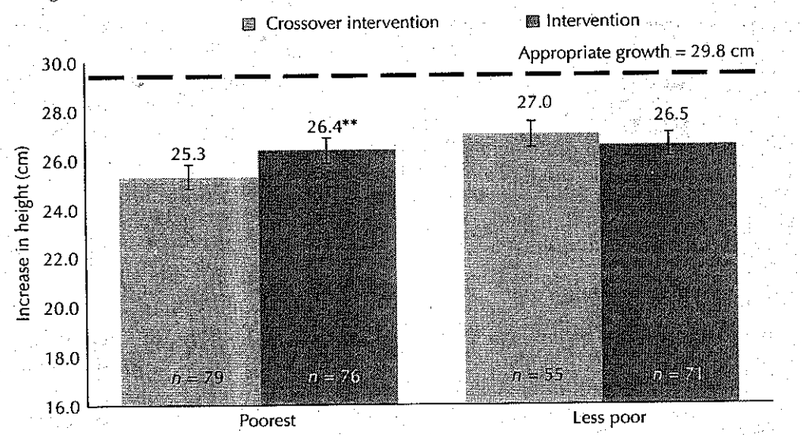


longed to the intervention group received the program benefits during the critical period of the first two years of life, while the crossover intervention group received the program benefits for only one year, starting at 12 to 18 months; i.e., they did not receive the program benefits for a significant part of the critical period (Figure 9). It was also hoped that the program would have the greatest impact on children from lower income families who showed the highest prevalence of malnutrition. For these reasons, all comparisons were made on the basis of age (< 6 months and 6–12 months at the beginning) and socioeconomic level (< middle or higher).

The less-than-12-month-old group covered from the beginning of the program was studied for the two years of the program. It consisted of 595 children (336 in the intervention group and 259 in the crossover intervention group) from 347 rural localities (205 Oportunidades and 142 control). The increase in height of each group was studied between the baseline (1998) and the year 2000, stratified by age and socioeconomic level, through a linear regression model with random coefficients adjusted in relation to the possible effect of conglomerates. It was found that in the baseline year the children of both groups were very similar in almost all their anthropometrical characteristics, as well as with regard to age, socioeconomic level, and sex. The effect of the program (Figure 10) was significantly greater in the intervention group vis-à-vis the crossover intervention group, but exclusively in the children less than 6 months old in 1998 and with the lowest socioeconomic level ($p < 0.046$). The effect on this group was on average 1 cm ($p < 0.05$), which is considered biologically important. There was no effect found on the group of children in the highest socioeconomic level nor among the oldest children.

With regard to anemia, in view of the fact that its effects appear within a shorter period of time, it was possible to evaluate the effect of the program in 1999, a period in which the

FIGURE 10. Adjusted increase[a] of size from 1999 to 2000 in infants aged 6 months during baseline measurement of the intervention and crossover intervention groups.



[a]Adjusted on the basis of age and length in 1988, using a linear model with random intercept.
**$p < 0.05$.
Source: Rivera JA, Sotrés-Álvarez D, Habicht JP, Shamah T, Villalpando S. Impact of the Mexican program for education, health and nutrition (Progresa) on rates of growth and anemia in infants and young children: a randomized effectiveness study. *JAMA* 2004; 291(21):2563–2570.

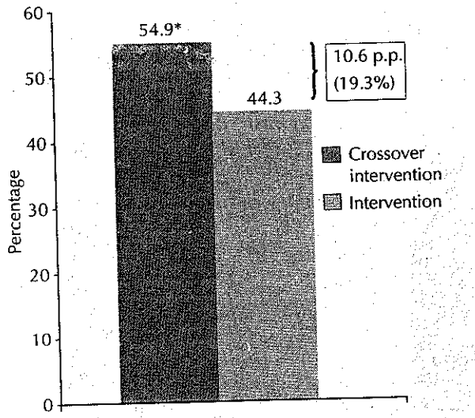
intervention group had received the program benefits for a year, while the crossover intervention group had not received them. In other words, in terms of anemia, it was possible to conduct the analyses in keeping with the study's original design. It was found that the prevalence of anemia, adjusted in relation to age, was significantly higher in the crossover intervention group (which was a true control during the first year) than in the intervention group (Figure 11). The effect was of 10.6 percentage points, almost a 20% impact with regard to the crossover intervention group.

In studying the consumption of the supplement by the beneficiary children, it was found that some 50% to 60% of the children in the intervention group regularly consumed the supplement, in keeping with the 1999 evaluation. It was also discovered that around 10% of the crossover intervention group regularly received the supplement, even though this group was not expected to consume the supplement during that period (Figure 12). As is customary in programs with broad coverage, there is a certain degree of diversion of the benefits to families not included in the program. This was possible since the supplements were distributed at health centers where families from communities that were not program beneficiaries came from time to time. In any event, since the crossover intervention group received the benefits for a year, and a small percentage of them even received them during the first year, the effects discovered under the study are clearly an underestimation of those that would have been found had there been a true control group.

The effectiveness study concluded that the program had an important impact on the linear growth of the group of children with the greatest nutritional vulnerability (< 6 months old and low socioeconomic level) and who were exposed to the program for two years, and that it was also able to decrease the prevalence of anemia in the children exposed to the program for a year.

The results of this effectiveness study on a program currently covering roughly 5 million households were of great importance in reaffirming the program's success and in presenting evidence in support of its continuity. Other results of the evaluation have been useful in providing feedback for the program and proposing changes to its design. Following are two examples of how the evaluation results have been applied to modify the program design.

FIGURE 11. Prevalence of anemia[a] in 1999 in the intervention and crossover intervention groups.

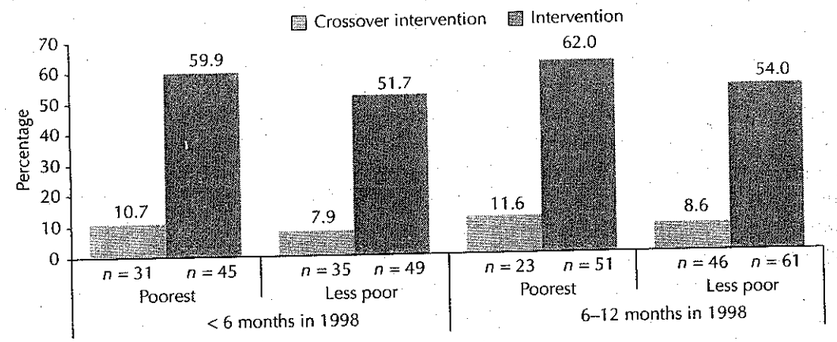


[a]Adjusted on the basis of age, using a GEE model.
*$p < 0.05$.
Source: Rivera JA, Sotrés-Álvarez D, Habicht JP, Shamah T, Villalpando S. Impact of the Mexican program for education, health and nutrition (Progresa) on rates of growth and anemia in infants and young children: a randomized effectiveness study. *JAMA* 2004;291(21):2563–2570.

HOW THE RESULTS OF THE OPORTUNIDADES EFFECTIVENESS EVALUATION HAVE BEEN APPLIED TO MODIFY THE PROGRAM DESIGN

One of the findings of the evaluation of the Oportunidades program's effectiveness (42) was that a significant percentage (40%–

FIGURE 12. Proportion of children whose mothers reported regular consumption (4 days a week) of baby food distributed by the Oportunidades program to the intervention and crossover intervention groups in 1999.[a]



[a]Adjusted on the basis of age.

Source: Rivera JA, Sotrés-Álvarez D, Habicht JP, Shamah T, Villalpando S. Impact of the Mexican program for education, health and nutrition (Progresa) on rates of growth and anemia in infants and young children: a randomized effectiveness study. *JAMA* 2004; 291(21):2563–2570.

50%) of the children for whom the fortified supplement was designed did not regularly consume the supplement (Figure 12). Upon studying the reasons for this low consumption, it was found that while the program was well accepted, low consumption might be attributed to the lack of timely availability of the supplement at the health centers as well as inadequate promotion of the supplement's consumption: only one out of 35 sessions was devoted to disseminating information on how to prepare the supplement and promote its consumption. Also, a very traditional educational approach was used under inadequate conditions: the talks were frequently held outside of the health centers where the women were standing and caring for their children under the hot sun. In summary, despite the many health and nutrition achievements of Oportunidades, its educational component remained weak and unsatisfactory.

A project was therefore developed, using a cutting-edge methodology for applying an educational communication component, including formative research and social marketing (*43*, *44*). The project was carried out in rural areas in two states: Veracruz and Chiapas, in both indigenous and nonindigenous communities. A communications strategy that included both mass and interpersonal media was designed and applied for four months.

A study of the preliminary results of this project indicates that it has had positive effects on various indicators of regular supplement consumption (*32*). This experience is currently being conveyed to the Secretariat of Health, which is implementing an educational communications strategy in four states, to be followed by a national strategy.

Another result of the evaluation of Oportunidades' effectiveness that led to modifying its program design was that it had had less of an impact on reducing anemia than expected and that it had not been successful in altering the status of iron in the children who had consumed the supplements (*42*). CINyS was informed that the type of iron added to the supplements was reduced iron, which is absorbed substantially less than other forms of iron (*45*). As a result, several studies were conducted on the bioavailability and acceptance of supplements fortified with two other forms of iron (ferrous sulfate

and ferrous fumerate) that showed adequate levels of bioavailability and acceptance (*28, 46*). This information has been provided to the Secretariat of Health with a recommendation to replace the reduced iron with one of the other two fortifiers.

The results of the effectiveness evaluation therefore provided valuable feedback for the program's coordinators and indicated needed changes in the design, thereby providing an example of the iterative, cyclical nature of mission-based research.

CONCLUSION

Strategic mission-based research (*1*) aspires to generate fundamental knowledge, with an effect on universal scientific tradition, which at the same time may be used to solve the population's health problems.

This chapter is an account of how the principles of strategic mission-based research, as applied to the design of CINyS' research agenda, have generated useful knowledge that has had an impact on the definition of public nutrition policies and programs and on changes to current policies and programs. The chapter also presents key scientific data that have provided the necessary input for designing these new policies and programs and for properly fine-tuning existing policies and programs.

In addition, as the list of references at the end of this chapter demonstrates, the research findings and their interpretation have generated fundamental knowledge that has been published in scientific peer review journals, in addition to being useful for public health in Mexico in general.

As stated at the beginning of this chapter, mission-based research addresses various objects of analysis, including health conditions and organized social response. The research examples shown encompass both of these objects of analysis. Thus, the results of the national nutrition survey reflect the extent and distribution of poor nutrition in Mexico (the study of the conditions), while the effectiveness evaluations presented refer to the analysis of policies (the organized social response). Furthermore, mission-based research addresses various levels of analysis, from subcellular particles up to health systems. CINyS conducts both clinical (studies on the bioavailability of micronutrients) and epidemiological or population research (the national nutrition survey or controlled tests) as well as research on health systems (evaluations of the program's coverage and effectiveness).

On the other hand, this chapter did not include examples of subcellular particle research (molecular biology) simply because, to date, CINyS has not addressed this level of analysis; nonetheless, subcellular particle analysis can be of great importance for the population's nutrition. For example, it can facilitate an understanding of the biological mechanisms involved in the etiology of poor nutrition and its consequences for health and intellectual performance, and an identification of biomarkers useful for diagnosing poor nutrition and for selecting the populations susceptible to specific deficiencies or to problems of obesity and their effects on health. At the same time, it could also be useful for developing resolution technology, for example, for food with nutritional or functional attributes aimed at reducing malnutrition. In short, addressing various levels of analysis, from subcellular particles up to health systems, is extremely useful for meeting the objectives of mission-based research.

Throughout the chapter, research experiences have been described that have successfully influenced the design of and changes to public policies. Highlighting success stories, however, does not mean that there have not been setbacks and failures along the way. The chapter does not describe several fruitless efforts made with a view to influencing public policies; attempts that resulted in frustration and skepticism among the Center's staff. The chapter likewise avoids a discussion of the difficulties in overcoming obstacles and moments of disillusionment

occasionally brought on by the same processes that eventually had an impact on public policies. It was simply determined that instead of addressing the hardships and discomforts common to any human activity that endeavors to reach noble ends, it was important to focus on outcomes that were successful and to outline the processes through which the objectives were met.

An especially important issue that remains for future endeavors is the possible reproduction of similar successful mission-based research experiences in other areas. In this regard, INSP successfully provided technical assistance to the health sector and to other governmental sectors in charge of health and nutrition policies from 1993 to 2005 (the author of this chapter can testify to this since the time period coincides with his association with the institution); to be precise, at least one of the important factors is institutional in nature and is based on current norms and standards.

Other factors are less related to institutionality and more related to people and interpersonal relations. The majority of the successes described in this chapter were made possible, to a large degree, through the participation of staff members who had vision and were convinced of the merits of informed decision-making that is founded on high-quality scientific research. These staff members were responsible for the decision-making with regard to food and nutrition policies. Without their dedication and resolve, it likely would have been much more difficult to influence public policy, even with institutional provisions and standards in place.

It was also essential to have the strong collaboration of INSP authorities who utilized their institutional investiture and broad personal relations to support the development of relevant research aimed at fueling decision-making and the dissemination of the research findings among staff members at a very high decision-making level.

Furthermore, as noted at the beginning of this chapter, the CINyS working group took active responsibility for disseminating the research results. In addition to disseminating study findings in scientific publications and academic presentations, the results were presented at a variety of forums to diverse audiences, including civil servants, non-governmental organizations, the media, the legislative branch, and business groups. The dynamism and diligence that accompanied the dissemination process surely influenced the success of the Center's work.

Finally, it is worth noting that the Center's researchers have taken great efforts to maintain a high level of quality in their research and to bring about permanent dialogue with political authorities interested in utilizing research for decision-making, which in turn has forged an environment of mutual respect and understanding.

In synthesis, over the past decade, CINyS has been able to conduct effective strategic mission-based research, thanks to the combination of an institutional framework that confers the INSP the standing of research adviser to Mexico's social, health, and development sectors; an environment characterized by civil servants with vision and dedication to producing research to be used for decision-making in public policy and institutional authorities committed to this type of research; and the dynamism, diligence, and high-quality criteria of a group of researchers who have achieved credibility and respect in the eyes of those responsible for public nutrition policies.

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