Worldwide, genetic diseases affect no less than 5% of all newborns. Most are caused by altered genes transmitted at conception, while a lesser share are due to chromosomal abnormalities—quantitative imbalances in the genetic material leading to various disorders including Down syndrome. The impact of these pathologies is especially severe because they are typically chronic, often affect more than one child in a family, and commonly demand expensive or inaccessible therapeutic methods. Current trends indicate that the demand for health services dealing with these and other congenital defects in Latin America will continue to grow, making it imperative that health plans include strategies for providing appropriate services.

The steps called for in seeking to provide such services are as follows: (1) clearly define the aims of the genetic health program; (2) assess, organize, and distribute the available human and material resources; (3) plan and implement primary care activities designed to detect genetic risk factors, and see that these are integrated into all relevant programs (family planning, prenatal care, etc.); (4) organize a referral network for complex diagnostic studies, genetic counseling, treatment, and rehabilitation; (5) encourage close collaboration between health planners and medical geneticists on education and health activities; (6) provide genetic health training programs for primary health care personnel; (7) develop genetic health education programs for the general public; and (8) adopt standardized procedures for supervising and evaluating these various activities and their results. By means of such strategies it has already been possible to considerably reduce morbidity and mortality caused by genetic problems in various parts of the world, including a number of developing countries.

Recent major advances in preventing, diagnosing, and treating genetic diseases have made it possible to appreciably reduce the suffering and death they cause. At the same time, progress in reducing infectious and nutritional diseases has increased the prominence of genetically related congenital diseases as a prime cause of childhood morbidity and death. While these trends are especially evident in industrialized countries, they can also be observed to varying degrees in many countries of Latin America and the Caribbean (1, 2).

At present, a number of different preventive and care-related genetic health services are being developed within the Americas. However, these services tend to focus on tertiary-level care centers and as a rule operate separately from general health programs. Moreover, despite sig-
nificant exceptions, public health organ-
izations have been reluctant to undertake
genetic health activities because they con-1 sider them "low priority" and exces-1 sively burdensome.

Given the fast-changing nature of the
genetic health field, there is good reason
to believe this reluctance is no longer jus-
tified. Specifically, I submit that in Latin
America (a) congenital diseases are a
leading cause of childhood morbidity and
mortality; (b) genetic health activities,
when based on a risk approach and con-
ducted in a primary health care context,
can significantly reduce the disease, suf-
fering, and death caused by congenital
defects; (c) currently available know-
ledge, equipment, and human resources
make it possible to develop effective pre-
ventive and care-related services; and (d)
appropriate organization and regionali-
ization of those services will make it pos-
sible to hold costs to acceptable levels.

GENETIC DISEASES AND
CONGENITAL DEFECTS

Before proceeding further, it seems ap-
propriate to review a few of the basic
concepts in the field of congenital defects
and genetic diseases.

The harmonious development and health
of human beings depend on the biological
functions of thousands of gene products
and their interaction with biopsychosocial
environmental experiences. Genetic dis-
eases are those pathologic manifestations
in which qualitative or quantitative alter-
ations of genetic material play a leading
role.

Genetic diseases are part of a larger
pathologic category, the congenital dis-
orders, which are caused by events oc-
curring before birth (either before, dur-
ing, or after conception). The clinical
manifestations of congenital disorders
(which may affect one or more organs)
can be structural (congenital malforma-
tions), or functional (affecting physical and
mental development), or both.

The term "congenital" signifies that the
basic (primary) defect is present at birth,
although it is not always symptomatic or
clinically demonstrable in the newborn.
As Table 1 indicates, the factors causing
congenital disorders can be genetic, en-
vironmental, or both.

Congenital Defects of Genetic
Origin: Genetic Diseases

Genetic diseases, congenital defects
caused by altered genes or chromo-
somes, are determined wholly or in part
at conception. Qualitatively altered (mu-
tated) genes capable of causing hereditary
diseases (one category of genetic disease)
typically have either dominant or reces-
sive patterns of expression. The domi-
nant disorders present clinical manifes-
tations when only one member of the
relevant gene pair is defective, and af-
fected children generally inherit the dis-
ease from an affected progenitor. The
recessive disorders present clinical mani-
festations only when both members of
the gene pair are defective; affected chil-
dren generally inherit the disease from
healthy parents, both of whom carry one
copy of the mutant gene.3

It has been estimated that the average
human being is a single-dose carrier of
roughly a half-dozen recessive genes that,
in a double dose, would produce dis-
eases of a serious nature. What enables
these recessive genes to remain relatively
common within the human gene pool is
their single-dose (and therefore inappar-
3A pathogenic recessive gene can also be expressed
and cause disease if it is carried on an unpaired
chromosome (notably the human X chromosome
in males), because in this case there is no matching
chromosome, and hence no sound paired gene
capable of offsetting the recessive gene's patho-
genic effects.
Table 1. Causes, classifications and examples of congenital defects.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Classification</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Genetic</td>
<td>Gene-determined hereditary diseases</td>
<td>Hemoglobinopathies</td>
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<td></td>
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<td>Cystic fibrosis</td>
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<td>Hemophilies</td>
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<td>Muscular dystrophies</td>
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<td>Skeletal dysplasias</td>
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<td>Mental retardation</td>
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<td></td>
<td></td>
<td>Deafness, blindness</td>
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<td></td>
<td>Chromosomal abnormalities</td>
<td>Down syndrome</td>
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<td></td>
<td></td>
<td>Turner’s syndrome</td>
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<tr>
<td>Environmental, intrauterine</td>
<td>Infections</td>
<td>Congenital rubella</td>
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<tr>
<td>(teratogenic)</td>
<td>Medications</td>
<td>Fetal hydantoin syndrome</td>
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<td></td>
<td>Radiation</td>
<td>Microcephaly</td>
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<tr>
<td></td>
<td>Drugs</td>
<td>Fetal alcohol syndrome</td>
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<td></td>
<td>Congenital malformations</td>
<td>Congenital heart defects</td>
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<td></td>
<td></td>
<td>Hip dysplasia</td>
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<tr>
<td></td>
<td></td>
<td>Cleft lip and palate</td>
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<tr>
<td>Mixed (genetic-environmental</td>
<td></td>
<td>Coronary arteriosclerosis</td>
</tr>
<tr>
<td>interaction)</td>
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<td>Essential hypertension</td>
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<tr>
<td></td>
<td>Common adult diseases</td>
<td>Malignant neoplasias</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manic-depressive psychoses</td>
</tr>
</tbody>
</table>

ent) transmission from one generation to the next.

Some 5 000 different inherited genetic diseases are known, among them the hemoglobinopathies, cystic fibrosis, the muscular dystrophies, the hemophilies, and various forms of deafness, blindness, and mental retardation. The individual frequency of each of these diseases is low (typically from 1 in 10 000 to 1 in 20 000 live births), although in specific population groups or regions of the world certain conditions are relatively common. For example, cystic fibrosis of the pancreas affects 1 out of 2 000 newborns of European origin; sickle cell anemia affects 1 out of 500 black newborns; and a similar situation exists with regard to the thalassemias of the Mediterranean and Southeast Asia. Worldwide, the hereditary diseases affect no less than 1% of all newborns.

The other category of genetic disease, chromosomal abnormalities, are characterized by a quantitative imbalance in the genetic material. As a rule, they occur as a result of sporadic errors in the cell divisions that produce gametes, leading to an excess or deficiency in all or part of a chromosome. On the average, 1 out of every 200 live births presents a chromosomal abnormality. Clinical manifestations include mental retardation and a variety of congenital malformations. Trisomy 21, or Down syndrome, is the most frequently occurring and best known chromosomal abnormality.

Congenital Defects of Environmental Origin

These defects, both functional disorders and malformations, result from the action of teratogenic factors that interfere with fetal development during gestation. The teratogenic agents can be infectious pathogens (e.g., the rubella virus), physical factors (e.g., exposure to various sorts of radiation, hyperthermia), or chemicals (e.g., illegal drugs, alcohol, environmen-
tal pollutants, pesticides, and certain medications such as anticonvulsants and retinoic acid). Although the frequency of congenital defects caused by teratogenic factors is unknown, it has been estimated that on the average at least 1 of every 200 newborns is affected.

Congenital Defects of Mixed Origin

Many congenital defects result from an interaction of predisposing genetic factors, present since conception, with triggering environmental factors that come into play before or after birth. This is true of various isolated congenital malformations (such as congenital heart defects, myelomeningocele, and hip dysplasia) as well as many common functional disorders (including diabetes, hypertension, arteriosclerosis, various different malignant neoplasias, manic-depressive psychosis, etc.). In this group of multifactorial congenital defects, the genetic factor is limited to playing a predisposing role. Environmental circumstances—whether dietary, psychosocial, or ones involving exposure to noxious substances—determine the development of the malformation or disease in question.

THE IMPACT OF CONGENITAL DEFECTS

Overall, congenital defects affect at least 5% of all live births. These figures are quite consistent throughout the world, regardless of the population's level of socioeconomic development and ethnic structure. In Latin America, as a result of diagnostic and health statistics deficiencies, information on congenital defects is fragmentary. However, data from a number of focal epidemiologic studies and from the Latin American Collaborative Study of Congenital Malformations have indicated that congenital defects occur in Latin America at frequencies similar to those found in other regions (3).

In most countries of the Americas, congenital malformations appear to rank between the second and fifth leading causes of death among infants and to account for between 2% and 27% of all infant mortality (4). For a number of reasons, however, these figures are only minimum estimates of the prevalence of congenital defects. Among other things, underrecording of congenital malformations is common. This arises partly from deficiencies in diagnostic capabilities; in addition, children with congenital defects are more susceptible to becoming ill and dying from exogenous causes (infections, malnutrition, abandonment), and these diagnoses rather than the underlying defects are what commonly appear in the statistics. In this same vein, most hereditary diseases, as well as most diseases with a mixed genetic-environmental etiology, are scattered throughout the International Classification of Diseases and do not appear under the category "congenital abnormalities" that serves as the statistical basis for estimating the frequency of congenital defects. For all these reasons, the contribution of congenital defects to childhood morbidity and mortality in Latin America is doubtless substantially greater than generally recognized.

It is also important to note that the relative role of congenital defects is changing. As the general indicators of child health improve, the relative contribution of congenital abnormalities to morbidity and mortality increases. This has clearly been the case in industrialized countries, where congenital abnormalities are now the leading cause of death during the first 4 years of life (5).

A similar situation has been found in certain Latin American countries that have managed to control the infectious and nutritional causes of morbidity and mortality (6–8). Overall, and despite obvious
differences between countries, the general trend in Latin America is likewise toward a gradual reduction of maternal and childhood morbidity and mortality caused by infections and malnutrition, and a proportional increase in the contribution of congenital defects. In this same vein, studies of hospital morbidity in certain Latin American countries indicate that between 10% and 25% of all pediatric admissions are associated with cases involving congenital defects (9, 10).

It should also be noted that the impact of genetic diseases and related congenital defects cannot be accurately assessed solely on the basis of morbidity and mortality data. Their actual impact is much greater than such data suggest, because these conditions tend to affect multiple organs and systems, are typically chronic in nature, and commonly demand therapeutic methods that are expensive and often inaccessible. Also, the children affected are generally more susceptible than other children to the damaging effects of adverse environmental factors—such as infections and malnutrition. In addition, these various problems are heightened by the fact that genetic diseases, because of their hereditary nature, commonly affect multiple children within a given family.

As these circumstances suggest, congenital defects have a considerable impact on affected families, especially among low-income groups. Indeed, the medical, psychological, and economic problems faced by families with children handicapped by congenital defects are enormous. Unfortunately, health systems and social services as a rule lack both the capacity and the appropriate resources needed to minimize the adverse impact of such abnormalities on the quality of life of the affected children and their families.

Current trends make it possible to predict that the demand for preventive and health care services dealing with congenital defects in Latin America will continue to grow during the 1990s. It is therefore essential that every health plan include strategies for providing these services. The sections that follow briefly assess the aims, content, and strategies of genetic health activities relevant to Latin America.

AIMS OF GENETIC SERVICES

The aims of genetic services are the following:

1. To minimize clinical manifestations in children born with congenital defects. Health systems should provide comprehensive secondary and tertiary preventive services for affected children by addressing their biological, psychological, and social needs.

2. To improve the quality of life of individuals with congenital disabilities and their families—by helping them to live and reproduce in the best possible manner.

3. To ensure that couples or individuals at high risk of conceiving a child with a genetic disease have appropriate information and support services (genetic counseling, prenatal diagnostic services) available in order to maximize the likelihood that any child born will be healthy while respecting both a couple's autonomy in the decision-making process and the couple's right to reproduce.

COMPONENTS OF GENETIC SERVICES

Early and Accurate Diagnosis

Early and accurate diagnosis of congenital defects is the basic prerequisite for all other genetic health activities. In the neonate, diagnosis will occasionally
depend on simple resources—such as mere observation in the case of external malformations like harelip and myelomeningocele, or physical examination in the case of hip dysplasia. Frequently, however, more complex diagnostic processes are required: radiology, sonography, biochemical analyses, chromosome studies, and others, depending on initial clinical findings. In general, the health services should seek to ensure the greatest possible coverage for early diagnosis of congenital abnormalities in the newborn child.

Certain serious congenital defects, such as congenital hypothyroidism and phenylketonuria, can be diagnosed biochemically in the newborn and treated extremely effectively, preventing the development and manifestation of the disease, so long as the treatment begins early. Certain other conditions, such as the hemoglobinopathies (sickle cell anemia, thalassemia), if diagnosed early, can be treated with measures aimed at preventing complications. Armed with this knowledge, a number of industrialized countries have launched population programs designed to systematically screen neonates for these conditions, provide diagnostic confirmation of positive cases, and offer lifelong treatment and follow-up of confirmed cases.

In Latin America, neonatal screening programs should be carefully planned and implemented. Clearly, the viability and effectiveness of these programs will depend on various administrative and budgetary requirements, as well as the state of development of genetic and general health services (11, 12). At present, Cuba is the only Latin American country where neonatal screening for congenital hypothyroidism, phenylketonuria, and sickle cell anemia is carried out fully and systematically (13).

No matter how complete and appropriate the system for diagnosing congenital defects in the newborn, a high percentage of conditions will be detected only when they begin to exhibit clinical symptoms during the first months or years of life. Hence, personnel charged with providing primary pediatric care should be trained to suspect genetic disease in children exhibiting external dysmorphisms or malformations, growth or developmental deficiencies, and mental retardation or disabilities unexplained by exogenous factors. Health services should establish and apply standards for pediatric care that will maximize the chances of suspecting genetic diseases and providing a prompt confirmatory diagnosis in such cases. Appropriate and conscientious monitoring of child growth and development is probably the most efficient way to achieve this goal.

Health services should also have available appropriately regionalized referral centers to confirm the diagnosis of genetic diseases and other congenital defects. Given the large number of genetic diseases affecting different organs and systems and the generally low frequency of each specific disease, such centers should count on a variety of different specialists and fairly complex diagnostic resources working together, including laboratories capable of conducting chromosomal, biochemical, and molecular analyses.

**Timely Treatment**

Appropriate diagnosis should be followed by timely treatment and prevention of complications. Since genetic diseases tend to affect multiple organs and systems, a multidisciplinary approach should be employed. In addition, since these conditions exhibit chronic manifestations throughout the life of the individual, the longitudinal continuity of care needs to be ensured. Also, the family into which a child with a genetic disease
or congenital defect is born suffers considerable emotional stress. Therefore, to maximize the benefits accruing to the affected child, the entire family needs to be cared for as a unit.

Improving the Quality of Life

This aim can best be achieved by stimulating the adaptive mechanisms of the child and his or her family, stressing favorable qualities and countering unfavorable ones. The rehabilitative needs of the affected individual must be satisfied, and he or she must be effectively incorporated into society, avoiding stigmatization and social discrimination.

Detection of Genetic Risk Factors

Family History of Genetic Disease

The most commonly occurring circumstance indicating genetic risk for a particular couple is the prior birth of an affected child. The risk of recurrence in a subsequent pregnancy will depend on the specific condition and its mode of inheritance.

Parental Consanguinity

A close blood relationship between healthy spouses increases the likelihood that both are heterozygous carriers of a single dose of the same defective (recessive) gene, and this heightens the risk of giving birth to a child with a recessively transmitted genetic disease.

Advanced Maternal Age

As the mother’s age increases, there is a corresponding increase in the prevalence of chromosomal abnormalities per live birth, these prevalences being approximately 1 in 500 at age 20, 1 in 400 at age 30, 1 in 200 at age 35, 1 in 50 at age 40, and 1 in 20 at age 45.

Ethnic-geographic Origin

Some genetic diseases are more frequent among certain human population groups. For example, sickle cell anemia is highly prevalent among blacks, thalassemias among individuals of Mediterranean or Asian descent (14), Tay-Sachs disease among Jews, etc. (10). Within this context, it is worth noting the presence of numerous high-prevalence areas or clusters of certain genetic diseases in Latin America. These include, among others, high prevalences of Huntington’s chorea near Lake Maracaibo in Venezuela, a type of mucopolysaccharidosis in the Aragua Valley of Venezuela, albinism in the Aicuña Valley of Argentina, congenital deafness in the Monges Valley of Costa Rica, and olivopontocerebellar ataxia in Cuba’s Holguín Province (15, 16). As such circumstances demonstrate, people’s geographic origins can be genetic risk indicators that require consideration.

Exposure to Mutagenic Agents

Exposure of future parents to certain types and doses of radiation, pesticides, food preservatives, and environmental pollutants, as well as exposure of their gonads to prolonged and excessive heat, can raise the frequency of genetic mutations in their germ cells and increase the risk of genetic diseases occurring in their children.

Fetal Exposure to Teratogenic Factors

In a similar vein, infectious, physical, and chemical agents can interfere with critical periods of fetal development and cause nongenetic congenital defects. Common infectious agents of this sort include rubella, herpes, HIV, and other
viruses, *Treponema pallidum*, etc.; teratogenic physical agents include various types of radiation and excessive hyperthermia; and chemical agents of this nature include alcohol, tobacco, and certain medications. In addition, certain maternal conditions (including malnutrition, diabetes, hypertension, and lupus erythematosus) can also lead to congenital defects.

**Genetic Counseling**

Detection of genetic risk factors should be an integral component of primary health care and should be followed by genetic counseling of the individual or couple involved. Genetic counseling entails informing the couple about the genetic risks for their progeny and presenting the various options available for addressing such risks. In those cases where the couple being counseled already has an affected child, efforts should be made to identify the cause of the problem and determine the risk of its recurrence in future pregnancies.

Without attempting to interfere with the reproductive autonomy of couples at risk, genetic counseling seeks to ensure that reproductive decisions are based on a knowledge of the existing risks, rather than on misconceptions. Experience indicates that most couples, when aware of a high risk of serious disease in their offspring, make efforts to avoid having any further children (17–19). On the other hand, when the risks or seriousness of the disease in question are low, most couples opt to proceed with plans to complete their families. In other words, genetic counseling, even though nondirective, tends to reduce the number of births of children with severe genetic diseases.

Within this context, one needs to remember that genetic counseling is a health service offered to individuals and should not have population-related or "eugenic" objectives. This counseling simply respects the right of every couple to be informed about their genetic risk, particularly if they already have an affected child. In other words, it enables the couple to decide which of the various reproductive options available—e.g., abstaining from having more children, considering adoption, accepting the risk, seeking prenatal diagnosis, etc.—seem best suited to serving their needs and interests.

**Prenatal Diagnosis**

A large number of genetic diseases and other congenital defects can be diagnosed in the early stages of fetal development (after the 10th week of gestation) by means of chorionic villi sampling, amniocentesis, or fetal ultrasound. Such prenatal diagnosis enables couples at high genetic risk to initiate (and maintain) pregnancies without fearing the birth of another affected child (20).

Genetic counseling and prenatal diagnosis are health services provided to at-risk couples, who decide voluntarily whether or not to accept them. Likewise, in the face of an abnormal result the decision to continue or interrupt gestation is a private decision of the couple, once they have been properly informed and counseled. This approach has been adopted by most of the world's countries, regardless of their economic development status, sociopolitical system, or prevailing religious beliefs. Hence, in each country it is the characteristics of the health system and prevailing health policies that determine the scope of coverage of such services. In Cuba, genetic counseling and prenatal diagnostic services are provided to the entire population in accordance with risk criteria and the availability of the services (13). In other Latin American countries, however, such services are generally restricted to the private sector,
and access to them is determined by ability to pay.

STRATEGIES FOR IMPLEMENTING GENETIC HEALTH SERVICES

The foregoing makes it clear that any effective genetic health program must be based on the following: (1) detection of genetic risk factors at the community level through broad coverage, followed by genetic counseling for couples at high risk and by prenatal diagnostic services (where these latter services are appropriate and when the couple has indicated a desire for them); and (2) integrated, multidisciplinary, and longitudinal care for patients with congenital defects.

Appropriate strategies for implementing such activities in Latin America have been developed by a number of WHO and PAHO expert committees (1, 2, 21, 22). Essentially, these strategies call for integrating the above-described activities into existing health programs operating in such areas as health education, family planning, prenatal care, neonatal care, child growth and development monitoring, special education, and rehabilitation of the handicapped. Each of these programs contains specific components that contribute to the primary, secondary, and tertiary prevention of genetic disease. These components include, among other things, detection of genetic risk factors; community education regarding such factors and how to prevent their consequences; and orientation and training of primary health care personnel in genetic health concepts.

In order for genetic health activities to be effective, they must achieve broad coverage, must be a component of community-based primary health care programs, and must be supported by a network of regionalized services of increasing complexity. With this aim in mind, the medical genetics centers already in operation in tertiary hospitals should be regionalized; in addition, they should take on the normative function of training and supervising health personnel—both at the primary and secondary levels and at the referral centers responsible for specialized laboratory analyses and for diagnosis and management of complex problems. In order for clear policies to be formulated and available resources effectively organized, a close interaction between medical geneticists and those responsible for public health programs is required.

Obviously, such an approach dictates a need to educate all health professionals, particularly those responsible for public health programs and medical geneticists. The former need to be able to correct misconceptions and acquire knowledge about the applications of genetics to public health. The latter must rid themselves of their excessively “curative” orientations and their fascination with rare and complex conditions, and assume a more preventive and outreach-oriented attitude in their relationship with the general public.

The right to health includes the right to be informed about ways to conserve health and prevent disease. The health sector is thus responsible for ensuring that those at high genetic risk are adequately informed about their risk and the various ways to prevent its consequences. In addition, inasmuch as the preventive efficacy of genetic health activities depends largely on the reproductive decisions of individuals, it is essential that health education in this area be made available to the community at large. Only in this way will it be possible to counter unfounded fears, correct misconceptions, and enable couples to freely and responsibly exercise their right to reproduce on an informed basis in the face of genetic risk. These educational activities,
combined with preventive and curative actions, will contribute to a decline in the frequency of congenital defects in the population and will improve the quality of care provided to those children who are born affected.

CONCLUDING REMARKS

Genetic and other congenital health problems contribute significantly to childhood morbidity and mortality in Latin America. The current state of health technology makes primary, secondary, and tertiary prevention of many of these conditions possible; furthermore, most countries in the region possess the human and material resources needed to launch the required programs.

The strategies needed for attaining the foregoing objectives are as follows:

- Clearly define the objectives of the genetic health program on the basis of the actual epidemiology of congenital defects prevailing in each country or area.
- Determine the human and material resources available for genetic health activities, direct them in accordance with the established goals, and organize them at the appropriate level of care (referral centers, intermediate level centers, and primary care centers).
- Plan and implement primary care activities aimed at detecting genetic risk factors: advanced maternal age, family history of genetic disease, ethnic or geographic origin pointing to one or another risk factor, consanguinity, exposure to mutagens or teratogens, etc. Such activities should be carried out by primary health care personnel and integrated into all other relevant programs (including family planning, prenatal care, postpartum care, infant growth and development monitoring, etc.).
- Organize a referral and cross-referral network for complex diagnostic studies, treatment and rehabilitation, genetic counseling, and prenatal diagnostic services, as required.
- Encourage the establishment of close interaction between those responsible for health programs and medical geneticists, within the context of education and health activities.
- Introduce genetic health training programs aimed at primary care personnel (physicians, nurses, auxiliaries, etc.), based on established aims and strategies.
- Develop educational programs for the general public in the area of genetic health; include the community in the decision-making process and activities relating to these programs.
- Adopt standardized procedures for supervising and evaluating the activities conducted and their results.

By implementing such strategies, it has been possible to considerably reduce morbidity and mortality caused by genetic problems in various different areas around the world, including a number of developing countries. The application of these strategies in Latin America will be contingent upon the policy decisions of those responsible for health plans in the various countries of the region.

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