Child Health Research

A Foundation for Improving Child Health

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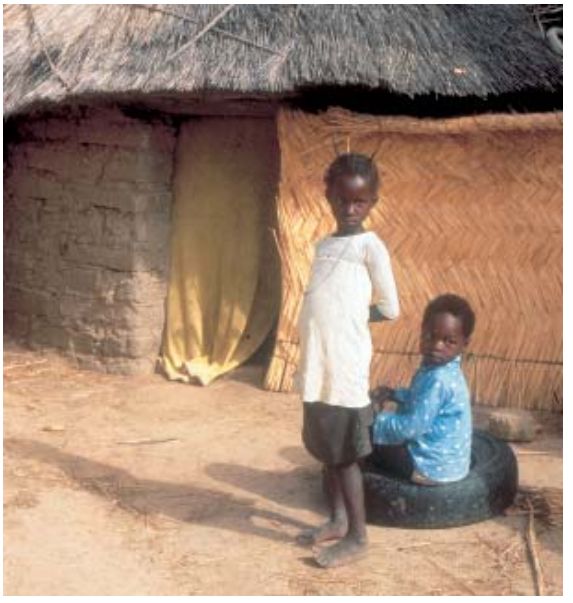

Global Forum for Health Research

Helping correct the 10/90 gap

World Health Organization

Foreword

Research makes a difference

Progress in public health depends on the systematic critical review and analysis of current practice with a view to doing things better in the future; this is the essence of research. The cycle of research, action, and evaluation leading on to more research, has provided the underpinning for many of the most remarkable achievements in global health exemplified by the dramatic declines in child mortality that have occurred over the past few decades.

Yet still today, there are many infants and children who have not benefited from such progress and for whom the fruits of research remain inaccessible. Of the five leading causes of premature death and disability in the world today, three are primarily or exclusively childhood diseases – respiratory infections, perinatal conditions and diarrhoeal diseases. Mortality rates among newly-born infants remain stubbornly high in many countries because mothers lack care during pregnancy and childbirth and babies do not receive essential newborn care. Each year, more than ten million children die before they reach their fifth birthday, most of them from just five conditions – respiratory tract infections, diarrhoea, malaria, measles and infections arising at birth. Underlying determinants include malnutrition, lack of access to health care and inadequate education, particularly in girls and women.

These deaths are all the more tragic because they are eminently avoidable given the widespread use of simple, cost-effective interventions such as integrated management of childhood illness and health care during pregnancy and childbirth. Research is essential to ensure that such interventions are made available to those in need. It provides the basis for the development of new and improved technologies and tools. It provides answers to questions such as how to ensure that beneficial family and community practices are reinforced and harmful ones abandoned. In the final analysis, all efforts to improve the survival, health and development of infants and children must start with research.

Lessons learned through past research include the importance of exclusive breastfeeding for reducing infant and childhood illness and death; the role of vitamin A supplementation in overcoming blindness and susceptibility to infection in children; and the value of oral rehydration formulations in diarrhoea management. Research will continue to be vital as we address emerging issues such as how to prevent transmission of HIV from mother to infant and how to enable every child to grow and develop to their full potential.

The international public health community has taken great strides in fighting the diseases that threaten children. But there is an urgent need to invest further in research, building on the lessons learned and the advances that have occurred to tackle the challenges of the future. Without further investment in research millions of children will continue to suffer and die from preventable causes each year with all the loss in terms of human growth and potential such deaths imply. No society can afford not to be involved in research which provides the basis for the future health and well-being of individuals and communities and underpins all our development efforts.

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Executive Summary

Successful societies safeguard their future by continually striving to improve the well-being of their children. They understand that healthy, well-developed, educated and respected progeny ensure that past achievements serve as the foundation for continuing progress.

Although child health has improved overall, three of the ten most important conditions of the global burden of disease still are diseases of childhood – respiratory infections, perinatal conditions and diarrhoeal diseases – causing over half of child deaths. Consequently, initiatives to improve child health can have an enormous impact on reducing the global burden of disease. These initiatives must start with research findings that are tested in the field and fashioned into interventions that help those in need. These interventions in turn raise fresh questions that stimulate additional research, beginning the cycle anew.

Over the last few decades, research findings have led to some very significant improvement in child health:

I. *Diarrhoea Management.* In the past twenty years, child deaths from diarrhoea decreased from 4.6 million to 1.3 million. Following the discovery of the efficacy of oral rehydration salts (ORS), continued research resulted in wider application of ORS and training of health workers and others to allow ORS administration in the field. Ensuing research led to new ORS formulations and even more effective interventions.

II. *Breastfeeding Promotion.* The global community recognizes breastfeeding as the primary nutritional support for infants and young children. In the 1900's, social change resulted in widespread use of breast milk substitutes. By the 1970's, studies confirmed the important role of exclusive breastfeeding in reducing infant and childhood illness and death. Numerous countries initiated programmes to promote exclusive breastfeeding. Recent research demonstrates that breastfeeding promotion programmes must go beyond the hospital setting and encourage community participation.

III. *Preventing Mother-to-Child Transmission (MTCT).* In the last two decades, studies revealed that an estimated 30 percent of HIV-infected women transmitted HIV to their newborn babies. Research has found that a number of interventions could significantly reduce mother-to-child-transmission. In high income countries, for example, anti-retroviral (ARV) administered prior to and during delivery, in addition with increasing caesarean section deliveries and use of replacement feeding succeeded in reducing MTCT to less than 2 percent of children born to HIV-infected mothers. The challenge now is to ensure that activities to implement these remarkable research findings reach those at greatest risk.

IV. *Remedying Vitamin A Deficiency (VAD).* VAD is a major cause of blindness in children and an underlying factor in death from diarrhoea and measles. In the 1980s, research found that children with eye infections linked to a lack of vitamin A died at a higher rate than their peers. Further investigation concluded that supplementing vitamin A in deficient children lowers their risk of death by 30 percent. The success of this body of research has led to global recognition of the perils of VAD, encouraged collaboration among health workers and resulted in the recognition of Vitamin A supplementation as one of public health's most cost-effective interventions.

Past research has also pinpointed some of the risk factors affecting child mortality and morbidity. These risk factors are
1. low birth weight, 2. poor nutrition,
3. adverse environmental conditions, and 4. the impact of poverty, including the impact of being orphan, and the inequitable distribution of resources.

Specifically with regard to these risk factors, we must undertake the following:

- To address low birth weight, new research is critical to developing and implementing even more successful maternal nutrition education programmes. We must also strive to improve our understanding of how to better promote safe motherhood programmes and pre- and post-natal care.

- In the nutrition field, new research is necessary to broaden understanding of how micronutrients work, identify those with micronutrient deficiencies and ascertain how to address these deficiencies more effectively. Research is also necessary to develop effective strategies to improve complementary feeding while maintaining and sustaining breastfeeding.

- Research to further explore the threats to child health posed by polluted air and water is essential to promote collaboration among the many sectors – economic development, environmental and health – responsible for dealing with these areas.

- Finally, the expansion of drug and vaccine research is crucial to addressing problems arising from inequitable distribution of research spending and will assist in fighting disease specific to poverty-stricken regions and countries.

Despite the successes, we still face a number of challenges:

- Without future research, we may have to revise upward current projections of the burden of disease for 2020 for conditions affecting children.

- Neonatal survival rates have improved only very slowly. New research is needed to develop more effective interventions to address the leading causes of neonatal illness and death and enhance community-based care.

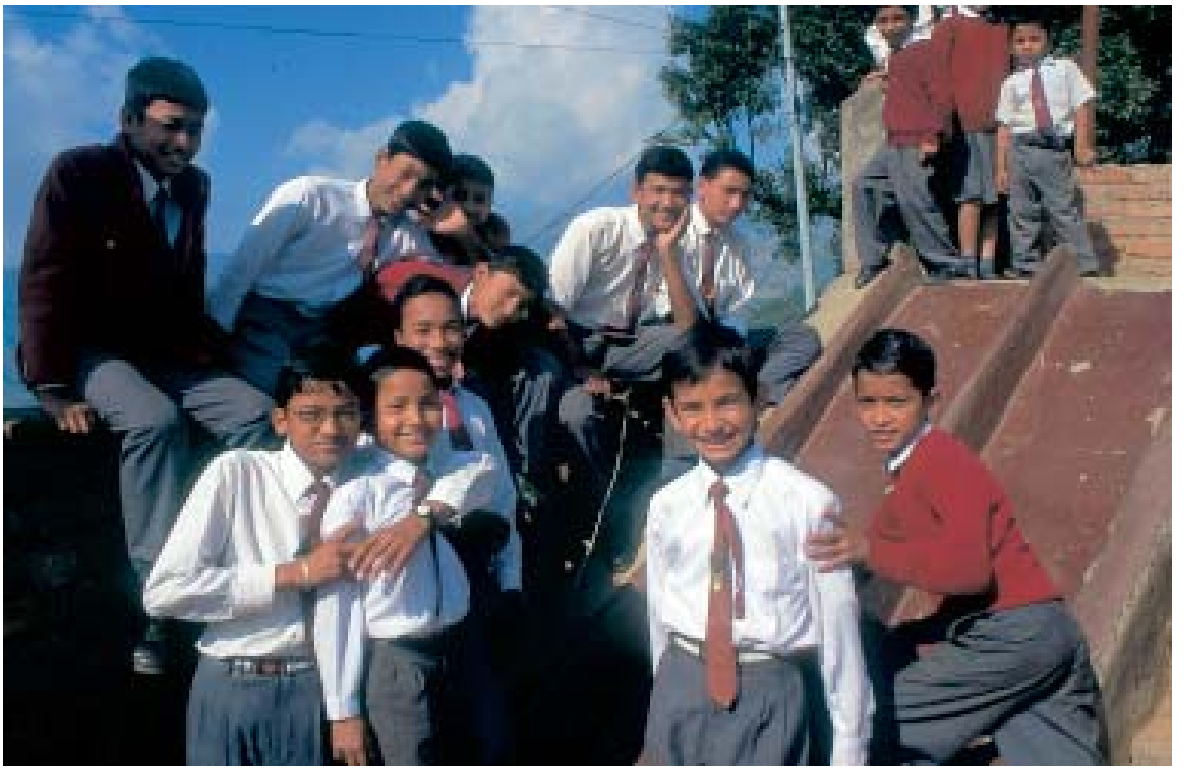
- We must learn more about the breadth of the HIV orphan problem so as to develop effective interventions and build consensus among stakeholders.

- Increased emphasis needs to be placed on conducting evaluation research to maximize the use of scarce funds and to prioritize child health interventions.

- We need research to develop innovative tools that enable health services planners to improve service delivery and better understand patterns of access to health care.

- Finally, we need research into various avenues of action to provide policymakers with greater knowledge regarding the programme options before them.

As this report details, the global effort to improve child health begins with research. Already, we have taken great strides to successfully deal with many of the conditions and diseases that threaten the health and development of children. But there is a critical need to invest in further research to build on the advances already in place. Without such an investment, not only are these advances put at risk, but the larger goal before us – to significantly reduce the global burden of disease – may never again be so attainable.



Introduction

Successful societies safeguard their future by continually striving to improve the well-being of their children. They understand that healthy, well-developed, educated and respected progeny ensure that past achievements serve as the foundation for continuing progress.

But building a society that nurtures healthy children is neither easy nor inexpensive. Decision-makers and others understandably are looking for health interventions that are swift, cost-effective and easily implemented. But the reality is that sustainable advances take time to develop and mature, and are based on research findings that are tested in the field and successfully carried out, reaching those most in need. These interventions stimulate additional questions and new research, thus beginning another cycle of action/research in turn leading to enhanced knowledge and even more effective interventions.

The goal of this report is to highlight how over time new knowledge has stimulated action and action, in turn, encouraged research. At the same time, the report outlines a number of research activities that are needed to advance and strengthen achievements to date, and the critical need to foster and promote expanded research in specific child health and nutrition priority areas.

This report is based on a systematic review of literature, direct consultations with institutions and scientists involved in research and programme implementation and a survey of relevant stakeholders in child health research in both low and high income countries (February–March 2001). Additionally, child health experts provided valuable input as part of a 3-day workshop jointly organized by the Global Forum for Health Research and the Department of Child and Adolescent Health and Development of the WHO, held in Geneva from 18–20 April 2001.

The State of Child Health Today

Children, as one of our most vulnerable populations, face unusually high health risks as they grow. With still-developing immune systems, they are completely reliant on others for their survival. The obstacles to optimal health are greatest for children born into poverty; those are also the most likely to be exposed to infectious disease and unclean water, and at the greatest risk of malnutrition.

As the following table illustrates, three of the ten most important conditions of the global burden of disease are major childhood diseases. Acute respiratory infections are the single most important cause of mortality in children under five years, accounting for two million deaths in this age group annually (1).

Particularly noteworthy is the fact that among the five most significant contributors to the burden of disease, three – lower respiratory infections, perinatal conditions and diarrhoeal diseases – are primarily or exclusively childhood diseases.

Although infectious diseases (respiratory tract infections, diarrhoea, malaria, measles and infections arising at birth) are the major killers of children, it should be noted that malnutrition contributes directly or indirectly to 60% of the more than ten million child deaths each year (3–5) (figure 1).

TABLE 1:
WORLD LEADING CAUSES OF DALYS[1] IN 2000

All causes	Rank	% of total
Lower respiratory infections*	1	6.4
Perinatal conditions*	2	6.2
HIV/AIDS	3	6.1
Unipolar depressive disorders	4	4.4
Diarrhoeal diseases*	5	4.2
Ischaemic heart disease	6	3.8
Cerebrovascular disease	7	3.1
Road-traffic accidents	8	2.8
Malaria	9	2.7
Tuberculosis	10	2.4

*Primarily or exclusively childhood diseases

[1] DALYs (Disability Adjusted Life-Years) are indicators of the time lived with a disability and the time lost to premature morality.

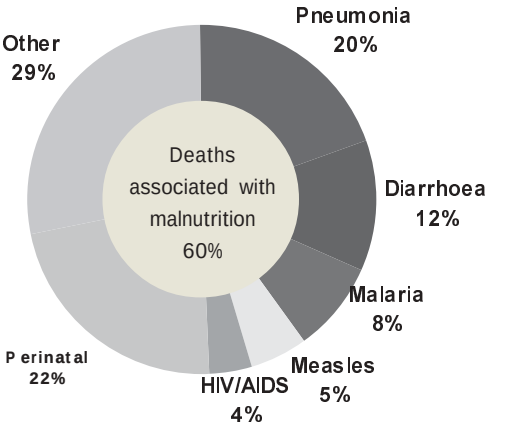


Figure 1: Major causes of deaths among children less than 5 years old in all developing countries, 2000.

Recognizing risk factors affecting child health

There is a limited list of factors that have the greatest impact on child health:

- Low birth weight
- Nutrition
- Environmental impact
- Poverty and inequity

Research has played a vital role both in identifying these factors and understanding the links between them. Research and information systems also help broaden our knowledge of these factors and the mechanisms by which they prevent illness or increase the risk of illness. Such knowledge, in turn, ensures that public health programmes set appropriate and feasible goals (6).

Low Birth Weight

Research tells us that the health of a child is primarily shaped by the health of the mother, starting with birth weight. Children born with low birth weight often have an impaired immune function, putting them at higher risk of infection and death. In Bangladesh, for example, it is estimated that 50 percent of all newborns suffer from low birth weight. Because these infants are more likely to become sick, eliminating low birth weight could prevent almost half of infant deaths resulting from respiratory infections and diarrhoea in that country (7).

Low birth weight infants who remain undernourished while developing as children and adoles-

cents will easily grow into undernourished women of childbearing age who themselves often deliver low birth weight infants (8). Thus, low birth weight is also associated with adult health, and the health of subsequent generations of children.

Improving the nutrition of women of childbearing age translates into reduced risks of having low birth weight babies. We must undertake new studies that further our ability to mount successful programmes in the area of maternal nutrition. Research has demonstrated that safe motherhood programmes lower the chances of delivering low birth weight babies. But we need additional knowledge to help health systems understand how to better promote such programmes and care – care that women in high income countries typically take for granted.

Nutrition

Both the quantity and quality of food are critical in determining how a child grows and develops. Malnutrition arises from both lack of availability of food, and from inequitable distribution of food within families, with young women and children too often receiving the least to eat (9).

While successful breastfeeding programmes are being implemented to improve early initiation of breastfeeding and exclusive breastfeeding in the first six months, similar efforts are not being made for improving complementary feeding. From 6 to 24 months of age is the period of most rapid decline in growth and rise in micronutrient deficiencies. The immediate causes of these conditions are inadequate intakes of energy and nutrients, and increased infections. Both of these immediate causes are directly linked with poor complementary feeding, and this in turn is part of the inadequate care of young children. Poor complementary feeding is not only a problem of low-income settings. In resource-rich communities, public health problems related to inappropriate complementary feeding include anaemia and risk factors for chronic diseases, such as obesity. Improving complementary feeding, in co-ordination with improved coverage with basic child health services, is essential to reduce under five mortality, morbidity and malnutrition. We must undertake new studies to develop effective strategies to improve complementary feeding while maintaining and sustaining breastfeeding.

The quality of food and the amount of valuable micronutrients it supplies contribute to improved child health. In some settings, micronutrients can be provided by supplementation. For example, zinc supplementation can reduce the incidence, duration and severity of diarrhoea and acute respiratory infections (10). Similarly, vitamin A supplementation can help strengthen a child's immune system and thus prevent death from infectious diseases. Research originally identified the role of micronutrients such as zinc and vitamin A and provided findings that resulted in

the establishment of supplementation policies and programmes globally (11).

Micronutrient supplementation is one important part of correcting malnutrition. New research to further understand how micronutrients work, to help determine those who are deficient, and how best to correct these deficiencies will contribute significantly to ensure that all children will benefit from such supplementation.

Environmental Impact

Environmental health factors contribute significantly to the incidence of child mortality around the world. Inadequate sanitation, poor housing conditions, and lack of proper personal hygiene, often aggravated by a scarcity of water, increase the likelihood of developing diarrhoea, especially in children. Research has confirmed that investing in clean water and sanitation is a critical element in reducing the rate of childhood diarrhoea (12).

Recent research has focused on indoor air pollution as a factor increasing the risk of respiratory infections in children. Half of the world's population and up to 90 percent of rural households in low income countries rely on unprocessed biomass fuels such as wood, dung and crop residues (13). These are typically burned indoors on open fires or in poorly ventilated stoves, creating high levels of indoor air pollution that increase risks of infection, possibly by suppressing the child's natural defences against infection (14).

The long-term and harmful effects of poor environmental quality result from the interaction of many dangerous elements: polluted air, unclean water and poor sanitation. Research into how these elements interact and adversely affect the health of children will help in promoting collaboration and teamwork among the many agencies – environmental, economic development and health, among others – responsible for dealing with these problem areas.

The Impact of Poverty and the Principle of Equity

Further complicating an understanding of risk factors is the wide-ranging and pernicious impact of poverty on rates of death and illness among children.

Research confirms that poverty is associated with higher levels of mortality. In 1996 in Zambia, infant mortality rates varied from 66 per 1000 live births in one of the country's most prosperous provinces to 158 per 1000 live births in one of its most remote provinces (15). This disparity, while significant in itself, is best put into perspective when compared to the estimated infant mortality rate of 5 per 1000 live births in high income countries.

The differences are indeed dramatic. A Zambian child under a year old in a prosperous province is 13 times more likely to die than a child of similar age in a high income country. And a child under the age of one in the poor province of Zambia has a risk of death roughly 2.5 times greater than that of the child in the prosperous Zambian province, or 32 times greater than that of the child in a high income country.

Effecting a 25 percent reduction in child deaths in a low income country might save twenty times as many lives as a similar reduction in a high income country, as the following table 2 indicates:

TABLE 2: SELECTED EXAMPLES OF INFANT AND CHILD MORTALITY (PER 1000), 1998 (2)

	Infant mortality (<1 year)	Child mortality (1–5 years)
Low income countries		
Uganda	107	181
Peru	45	71
High income countries		
France	6	8
Japan	4	6

A host of scientific, financial and environmental concerns – on both the global and national level – determine the context and direction of child health research. For example, the different living and health conditions of children in Norway compared to those in Chad will give rise to different health problems and research needs (15).

Recognizing these differences raises questions concerning equity. We know that geographic, economic and cultural accessibility to health services by mothers is a major determinant in obtaining timely care for children (16). And we understand the close linkage between child survival and the international economy. For example, although pneumonia and diarrhoeal diseases represent 15 percent of the global burden of disease, and a much higher proportion of that among children, total research spending on these two conditions amounts to roughly 2 cents of every ten dollars spent on health research annually (17, 18). With such low levels of research spending on the types of disease that affect children the hardest, few new drugs, vaccines or other interventions are emerging. Developing effective interventions for diseases such as human immunodeficiency virus (HIV) infection, tuberculosis (TB) and malaria too often are secondary to designing and implementing new technologies for chronic conditions affecting adults, and most often, adults living in high income countries. In some cases, patents and licensing requirements are barriers to increasing access to drugs for people in low income countries, such as the case with anti-retroviral drugs that reduce mother-to-child transmission of HIV. But even on this high-profile issue, a drug alone is not the answer if there exists no health system to conduct the needed testing, dispense the drug to those in need, and reach women who may live miles from the nearest hospital.

Building on the Research Foundation: Four Case Studies

Different types of research contribute in different ways to our knowledge base, as the following table shows:

TABLE 3: THE DIFFERENT TYPES OF RESEARCH IN CHILD HEALTH AND NUTRITION

Type of research	Objective	Significant research finding
Descriptive epidemiology and burden of disease	To describe the magnitude of the problem, to identify the causes of child illness and death in different communities	Malnutrition contributes directly or indirectly to 60% of child deaths each year
Aetiology and mechanisms	To understand the determinants of childhood disease	*S pneumoniae* causes 50% of early infant meningitis (19)
Development of interventions	To design the most appropriate strategies to improve child health	Teaching mothers to promptly provide anti-malarials to sick children at home decreases under five mortality (20)
Impact and evaluation	To measure the effect of the implemented strategies and raise new research questions	Less than half of children in western and central Africa are currently receiving measles vaccine (21)
Health systems	To increase the effectiveness of child health interventions and services	Increasing private practitioners' performance is likely to decrease childhood mortality (22)
Policy	To analyze retrospectively and monitor prospectively the scaling-up of child health and nutrition interventions	Social marketing of insecticide-treated nets contributes to improving child survival (23)

Four real-life case studies demonstrate how research leads to both finding and implementing successful interventions:

Diarrhoea Management

Until the 1940's, diarrhoea was a major cause of morbidity and mortality in children in high income countries. Today, it continues to be a significant concern in low income countries. In 1980, an estimated 4.6 million children under 5 years of age died annually from acute diarrhoeal diseases (24), the overwhelming number in low income countries. In 1990, child deaths from diarrhoea decreased to 3.2 million (25). In 2000, this number was 1.3 million children, a 65 percent decrease in diarrhoeal mortality over twenty years (1, 26).

The steady progress in reducing childhood deaths from diarrhoea is a stunning demonstration that the research–action–research cycle can dramatically impact the state of child health across the globe.

Until the 1960's, intravenous (IV) infusion was the primary treatment for dehydration due to severe diarrhoea (27). At that time, however, research studies suggested that oral rehydration salts (ORS) might be as effective as IV therapy while being much simpler to administer (28). In Bangladesh, *in vitro* research helped to further understand how sodium traveled through the gut mucosa (29) and led to the development of ORS formulations that were tested on adult cholera patients in hospital-based clinical trials (30). Although proven to be less expensive and easier to administer, use of ORS solution was still limited to hospital settings, simply replacing IV therapy. In the early 1970s, applied experimental research in India (31) showed that health workers (non specialists) outside hospital settings could administer ORS solution with great success. This field study, carried out in a refugee camp during a cholera epidemic, was the critical turning point in demonstrating the vast potential of ORS therapy.

Before the global community fully accepted the efficacy of oral rehydration therapy (ORT), researchers undertook additional field tests. In the Philippines, an important community-based study demonstrated the effectiveness of ORT (32). Subsequent research successfully broadened understanding of how to minimize constraints to implementing ORT in general population settings and demonstrated the importance of community participation, skills needed to prepare ORS solution, and training of health workers (33-35). Another study in a children's hospital in Mexico found that making available an oral rehydration unit reduced the number of inpatients with diarrhoea by 25 percent, thereby significantly reducing health care costs (36).

The knowledge acquired through this body of research led to the creation in 1980 of the Programme for the Control of Diarrhoeal Diseases (CDD) of the WHO, aiming to reduce childhood mortality due to diarrhoea. This Programme was the first created within WHO as an action *cum* research Programme: it encouraged continued interaction between action and research to modify and improve the interventions and strategies promoted by the Programme (37). By 1990, approximately 99 percent of the population of the developing world lived in countries with national CDD programmes.

And the cycle continues: over the past two decades, research pointed the way to the development of an improved Oral Rehydration Salts solution to reduce stool output, vomiting and the need for unscheduled IV therapy (38). Research also led to global recognition that persistent diarrhoea and dysentery are major public health problems. This recognition, in turn encouraged further clinical research to design appropriate clinical treatment guidelines for both conditions. Throughout the 1990's, research has helped to measure the large-scale impact of these national CDD programmes at the country level (39,40). Anecdotal reports of the disappearance of rehydration wards in primary care hospitals testify to the success of ORT and the clinical management of diarrhoea.

Research supported by the CDD Programme revealed that often children die from a multitude of causes and that management of child illnesses

should be integrated. With this finding, the CDD Programme evolved from a single disease programme to a department that considered child health in its totality, and from promoting a single intervention into the WHO/UNICEF Integrated Management of Childhood Illness (IMCI) strategy (11).

The implementation and evaluation activities of the CDD Programmes continue to provide invaluable feedback and to raise new challenges and questions, thus demonstrating that research is an ongoing instrument of progress. The exciting success of the CDD programme taught some important lessons:

- Research followed by implementation followed by research made possible the development of an effective tool to improve child survival, namely ORT.
- Over the years, documenting the impact of research findings and their application on a large scale has been important in enlisting support for replicating this successful initiative.

Breastfeeding Promotion

Breastfeeding is recognized around the world as the primary nutritional support for growing infants and young children. But this was not always the case. By the end of the 19th century, the industrial revolution and the changing role of women in society gave rise to alternative feeding regimens, including the use of baby bottles and condensed milk. Initial concerns about the risks associated with bottle feeding faded with a reduction in infant mortality brought about by improvements to water and sanitation, better hygiene practices and other changes related to infant development. Throughout the 1900's, manufacturers of breast milk substitutes heavily promoted their products, and the use of such substitutes spread rapidly. However, in the 1970's, epidemiological studies confirmed the important role of exclusive breastfeeding in reducing infant and childhood illness and death (41,42). In the next decade, numerous low income countries initiated programmes to promote exclusive breastfeeding.

Advocacy groups came together to encourage exclusive breastfeeding and launch a universal campaign against the manufacturers of breast milk substitutes. The advocates succeeded in curtailing a number of questionable marketing practices and were instrumental in formulating rules of conduct dealing with the promotion of breast milk substitutes.

Recent research has shown that initiatives promoting exclusive breastfeeding should not only be carried out in hospitals but must also encourage community participation (43,44). Today, based on this evidence, many countries are implementing breastfeeding intervention programmes, with the active support of WHO, UNICEF and other international agencies, advocacy organizations, and scientists.

Again, the cycle of research – action – research spurred significant improvements in common, accepted practice:

- Multi-sectoral research studies documented the need to develop breastfeeding interventions but also pointed out the inefficiency of initial programmes.
- The participation of different specialists (biomedical researchers, epidemiologists, anthropologist, psychologists, communicators and economists) was essential to an in-depth understanding of the problem.
- The involvement of advocacy groups and civil society institutions turned the spotlight on the dubious promotional practices of the manufacturers of breast milk substitutes. These groups also successfully influenced many governments to develop appropriate breastfeeding policies.

Although many countries have established breastfeeding education programmes, to date very few have evaluated their impact on child health. However, one evaluation of a programme in Belarus showed an increase in breastfeeding correlated with a significant reduction of gastrointestinal infections and eczema in infants (45). There is an urgent need to undertake similar evaluations in other countries as well as to determine the cost of and cost-savings resulting from such an intervention.

Preventing Mother-to-Child Transmission of HIV (MTCT)

In the late 1980's and early 1990's, epidemiological studies found that approximately 30 percent of HIV-infected mothers were transmitting HIV to their newborn babies. The resulting increased burden of disease was especially significant in countries in sub-Saharan Africa, a number of which were experiencing HIV+ prevalence rates in pregnant women approaching 30-40 percent (46).

Research on the aetiology and mechanisms of childhood HIV infection revealed early in the epidemic that mother-to-child transmission (MTCT) of HIV can occur before and during childbirth and through breastfeeding (47). Carefully conducted multi-center clinical trials in such

countries as Côte d'Ivoire, Burkina-Faso and Thailand (48–50) demonstrated that anti-retroviral (ARV) therapy (developed originally for use with HIV-infected adults) administered prior to and during delivery significantly reduced MTCT of HIV. Changing certain birth practices, increasing caesarean section deliveries and using replacement feeding were found to further reduce MTCT of HIV in Europe and in the USA. Using these strategies and interventions, industrialized countries succeeded in reducing MTCT of HIV to less than 2 percent of children born to HIV-infected mothers in the year 2000.

Recent observational studies have suggested that exclusive breastfeeding, with no other fluids or foods provided to the infant, also significantly reduces the risk of postnatal HIV transmission through breastfeeding in settings where safe alternatives to breastfeeding are not readily available (51). A 1999 research study in Uganda discovered that a single dose of nevirapine, an anti-retroviral drug, significantly lowered by half MTCT of HIV during delivery (52).

The success of this body of research to date enables countries and international organizations such as WHO, UNICEF and UNAIDS to make informed policy decisions to effectively combat MTCT of HIV (53).

Again, the cycle of research – action – research teaches lessons with broad applications:

- The dramatic reduction of MTCT of HIV in high income countries shows that large, sustained and coordinated research efforts with clear specific goals can quickly yield tangible results with potentially far-ranging impact.
- In less than ten years, science has developed evidence-based strategies that can effectively eliminate MTCT of HIV but unless these

> strategies are universally applied they will never achieve their potential to save lives. The great challenge for the global health community is to ensure that these remarkable scientific achievements reach those at greatest risk (54).

New research is necessary to examine behavioural, social, cultural and economic factors that limit access to and use of effective interventions, including HIV voluntary counselling and testing by pregnant women (55). More basic and clinical research is also essential to continue to reduce MTCT of HIV. Finally, impact evaluation is needed to ensure that when interventions are applied on a large scale, the results are positive for women, children, families, communities and societies.

Vitamin A Deficiency

Vitamin A deficiency (VAD) is found in 70 countries, most located in Asia and Africa. VAD is a major cause of childhood blindness and an underlying factor in increased mortality from measles and diarrhoea. In the early 1980's, observational research in Indonesia showed that children with clinical eye signs of VAD died at much higher rates than their peers (56). Several clinical research trials confirmed this observation; the first of these trials showed that a population of Indonesian children who received vitamin A capsules had 34 percent fewer deaths (57). Another eight large supplementation trials and several meta-analyses of their results concluded that improving the vitamin A status of deficient children significantly lowers their risk of death by about 30 percent (58–60). A South African study on paediatric HIV infection showed that HIV-infected children who received high-dose vitamin A supplementation every 3–6 months experienced a speedier recovery from diarrhoea (61). A Tanzanian study published in 2000 confirmed these results (62).

In its 1993 report, "Investing in Health," the World Bank identified vitamin A supplementation as one of the most cost-effective health interventions in all of public health (63). Based on this, international agencies in collaboration with numerous government health ministries have trained health workers to distribute vitamin A and to provide expertise in establishing programmes to fortify food with the vitamin.

This field of endeavor again demonstrates how research informs action, which in turn spurs additional research:

- Wide dissemination of research findings by international agencies encouraged many countries to examine the prevalence of vitamin A deficiency in their child populations.
- Developing indicators for assessing vitamin A status enabled countries to more accurately assess their own particular problem.
- Social marketing, education and communication strategies encouraged behavior change and modification of dietary practices. These efforts were essential elements in the success of many programmes.
- Integrated programmes, such as IMCI, offer the possibility of more consistent coverage and sustainable delivery.
- Well-trained health workers are vital to ensuring effective implementation of programmes to combat vitamin A deficiency.

Further research is required in the area of monitoring and evaluation of national programmes already in place. In addition, slightly more than half of the 70 affected countries have national programmes in place; efforts must be undertaken to encourage those remaining to initiate supplementation activities and those countries with existing programmes to improve their outreach to children who do not normally use health services.

Strategies for Child Health Research

The child health research community has come together to recognize and adopt a number of key strategies, including:

- Setting priorities
- Encouraging national ownership
- Strengthening the link between research and implementation
- Communicating and disseminating research findings
- Fostering a multi-sectoral approach

Setting Priorities

Over the past few years, WHO, the Global Forum for Health Research (GFHR) and the Council for Health Research and Development (COHRED) have implemented several priority setting exercises designed to maximise the efficiency and responsiveness of child health research (1,17,64). These institutions agree that research priorities should:

- be based on global disease burden and strong epidemiology;
- consider long-term ownership and partnerships that increase global research capacity;
- respect ethical issues; and
- address the interactions between child health and other sectors.

These principles are essential to encourage the development of more cost-effective interventions for use where the needs are greatest, to broaden the focus of research beyond a search for narrowly targeted "magic bullets", and to improve the allocation of research resources.

Encouraging National Ownership

The key players in child health research at the national and international levels include governments, international organisations, health care providers, non-governmental organisations (NGOs), civil societies, scientists and academics. The challenge is to coordinate the input of these various elements, at the same time recognizing the need for "locally-owned" and relevant research endeavours.

Furthermore, national ownership makes research findings more compelling and will be more likely to bring about a programmatic response (65). Consequently, countries need a research capacity that will enable them to identify, understand and address their own problems (66).

Strengthening the Link between Research and Implementation

Research on implementation, on policy-making or on programme development are as important as basic clinical research for improving child health. Frequently, research findings can be implemented with relatively modest and cost-effective modifications to health system delivery. However, in some specific areas the process of translating research findings into effective health interventions can be complex and difficult. For example, implementing research findings aimed at preventing mother-to-child transmission of HIV involves a number of elements: drugs must be available, health services accessible and used, quality maternal and child health care provided, and adequate HIV testing and counselling services in place (67). The implementation of new interventions on a general population basis raises additional questions and requires further knowledge of health seeking behaviours and cultural and personal beliefs.

Communicating and Disseminating Research Findings

The manner by which knowledge acquired through research is communicated will determine how widely that knowledge is acted on. Recommendations based on research results need to be made understandable to policy- and decision-makers. It is therefore important to identify appropriate means of communication, and select the most suitable partner(s) to promote and support action.

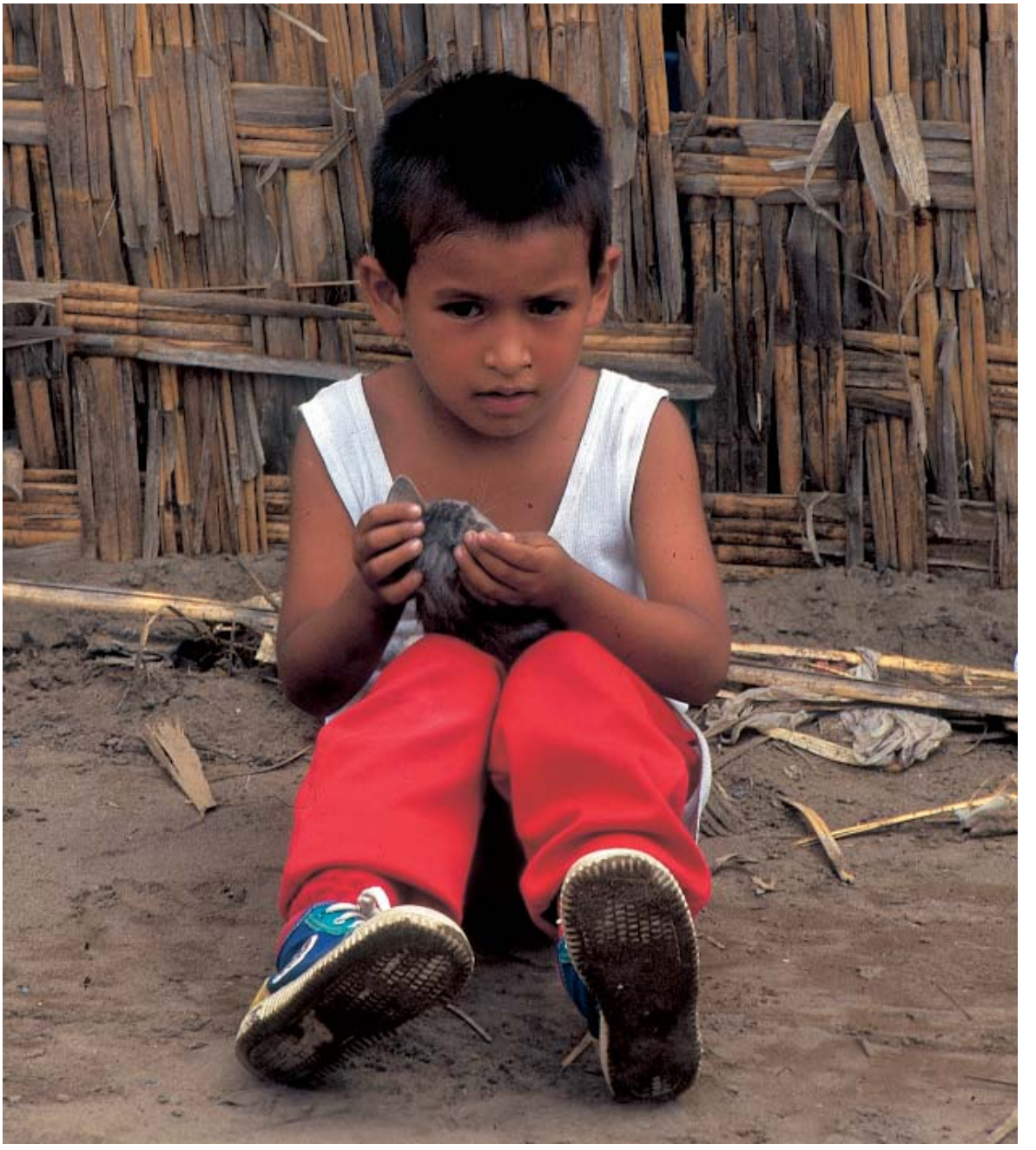
This strategy requires sustainable and comprehensive information systems. As cutting-edge dissemination vehicles (such as the Internet) evolve and spread, global communication can be a powerful medium in diffusing knowledge and sharing experience. Properly applied and used, these new communication tools can speed up the utilisation of research findings in the field.

Fostering a Multi-Sectoral Approach

In the field of child health research, involving the local population, who often have a broader view of health problems than researchers, encourages a holistic approach to understanding what determines good child health. If the ultimate objective is developing effective, sustainable health programmes based on well-conducted research, the early participation of a number of community elements, such as NGOs, health workers, religious leaders and women's groups is crucial.

Child health research, aimed at bettering the lives of children, is also closely linked to poverty alleviation and economic development initiatives. For example, efforts to reduce exposure to indoor air pollution must also address related concerns dealing with domestic energy requirements, cultural practices and values, safety, fuel efficiency and environmental protection (13).

The successful implementation of diarrhoeal disease prevention strategies, which require the cooperation of various sectors (education, agriculture, water supply and sanitation) complementing individual case management, is clear and compelling evidence that there are no "magic bullets" in public health. Indeed, even interventions such as immunisation or promotion of the rational use of antibiotics need well-nourished children, adequate sanitation, and control of other diseases to be most effective. The lessons of the past, reinforced by experience in the last decade, confirm that no single intervention has been successful in and of itself (68).



Is the Finish Line in Sight?

Without doubt, we have made significant progress in improving the health of children. But these improvements are uneven and vary within regions and even within countries. And each year, more than 10 million children under the age of 5 continue to die from conditions that are preventable. Our successes – while dramatic – also tell us that we need new strategies, new tools and new interventions. Innovation can only result from thoughtful, ongoing research. The following describe some of the challenges ahead in a number of areas of research:

Epidemiology and Burden of Disease

WHO projections of the burden of disease for the year 2020 indicate that child diseases and the nutrition-related illnesses they suffer will decline in proportion to non-communicable conditions and injuries, in part due to decreasing fertility and longer life expectancies among adults (1). These projections assume that the future pace of research into tools and implementation strategies will be as intensive and focused as research conducted over the past 50 years. Accepting this as a given, however, is a grave risk. Unless we secure funding for future research, we predict that the projections of the burden of disease for 2020 will have to be revised upward for conditions affecting children.

Developing New Interventions

– *Perinatal and neonatal mortality*. In contrast to significant improvements in child survival rates over the past three decades, neonatal survival rates have improved only very slowly. The majority of the eight million deaths in infants under the age of 1 are occurring in infants in their first 28 days of life (69). In many countries, a substantial proportion of births occur outside a hospital setting and too few women seek assistance from a trained birth attendant or other health worker. In Nepal, research estimated that establishing community-based midwife-run delivery units could dramatically reduce the incidence of unplanned home deliveries, thus lowering neonatal mortality rates (70). Additional research is needed to develop other effective and sustainable interventions to deal with the leading causes of neonatal morbidity and mortality, as is operational research to enhance community-based care, to expand appropriate referral to health workers and to improve monitoring after birth.

– *HIV/AIDS Prevention and Care.* As the HIV/AIDS epidemic continues to take its toll among the child population, we must ascertain the most appropriate protective responses in resource-poor settings (71). The number of children orphaned as a result of the epidemic is projected to rise from 25 million in 1990 to 41 million by 2010, a 64 percent increase (72). The full extent of the HIV orphan problem remains unquantified and there is an urgent need for a situation analysis both to generate knowledge necessary to develop effective interventions and to build a consensus among key stakeholders.

The research required should focus on the morbidity-mortality patterns of uninfected and infected children born to HIV-infected mothers as well as on their quality of life. Such research will aid in designing effective governmental policies that will expand the definition of care and support for orphans to include non-medical approaches. Currently, the majority of programmes serve already-orphaned children; future research should explore what is needed to target children prior to the death of their parents, which may be a more cost-effective intervention.

Other research required includes additional biomedical studies on the use of anti-retroviral therapy for HIV-infected children and examination of the psychosocial consequences and developmental impact of paediatric infection. Although NGOs have been involved in research concerning stigma and discrimination surrounding HIV-infected children and youth, answers are still lacking in a number of areas, including:

- the integration of HIV-infected children in the community;
- the quality of psycho-social support to affected families;
- the development of protective structures for care and support (i.e., community-based child care centres); and
- assisting children to live with a chronic disease.

Impact Monitoring and Evaluation

Monitoring the on-site implementation of a health intervention or programme is essential to understanding and designing needed modifications. Evaluation also can identify the most cost-effective interventions and programmes. Unfortunately, insufficient attention is directed to evaluation research even in a time of scarce resources, when such knowledge is most needed and valued. Furthermore, when monitoring and evaluation are carried out, they often are restricted to counting the number of drugs provided rather than measuring the number of deaths avoided. Designing and conducting evaluation research contributes to maximizing the use of often-scarce funds and to prioritizing effective child health and nutrition interventions.

Health Systems Research

Health systems and services are intrinsically uneven in the efficiency and equity of care they offer. Today, research is underway to compare these parameters among countries.

Access to health care is one of the main factors to reduce child morbidity and mortality, yet the tools to measure the coverage and use of services are inadequate. Assessing local environmental, social and health resources will ensure the provision of appropriate and relevant health services in specific settings. Some child health researchers have explored various tools to do this, ranging from direct interviews to examining the usefulness of a Geographical Information System (GIS) to improve understanding of health problems, policies and practices. One 2001 study in Bangladesh, for example, examined how the methodological tools of a GIS can be used to investigate geographic variation in health care resources and to determine how a patient's geographical location can be correlated with adverse outcomes of disease (73). Providing health services planners with such tools facilitates improved service delivery and fosters a better understanding of patterns of access to health care, both of which can reduce child mortality.

Policy Development

Integrating research findings into policy development is a complex process. Defining and developing policy – understanding options, choosing the right course of action, allocating scarce resources – must be coupled with a set of facts that looks at the appropriateness, sustainability and cost-effectiveness of interventions, competing priorities and the realities on the ground. Research into the wide-range of avenues for action can provide information to policymakers who must compare and choose among several programme options.

Conclusions and Recommendations

The goal of this report is to highlight the practical application of research results aimed at improving and advancing child health around the world. In doing this we have examined successful cases in which the combination of research and action proved to be a major determinant in enhancing child health and those areas in which additional research is needed to advance gains already achieved.

Improving child health, development and nutrition relies to a great extent on understanding the causes of child morbidity and mortality. Programmes and policies aimed at improving the health of children need to be grounded in appropriate research conducted in the real world of competing priorities and realities. Short-changing our investment in research means that millions of children will continue to die from preventable causes each year and not only threatens the future of children but our collective future as well.

In summary, this report presents the evidence that:

- Health research is critical to continuing the progress already made in programmes and policies that have resulted in improved child health.
- Child health research must address the leading causes and determinants of morbidity and mortality at different stages of a child's development and identify and implement interventions that address these causes.
- Directly involving scientists, health care providers and concerned individuals in all countries, both rich and poor, in child health research efforts will broaden and enhance these efforts.
- Improving child health requires investments to broaden the research capacity of each low income country to ensure that research addresses local needs and that effective interventions are responsive to local requirements.

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– Institut d'Epidémiologie, Santé Publique et Dévelopment (ISPED), Bordeaux, France (Prof François Dabis – Project Director) and

– Department of Paediatric Epidemiology, Institute of Child Health (ICH), University College, London, United Kingdom (Prof Marie-Louise Newell).

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ACRONYMS

ARI:	Acute Respiratory Infections
CHNR:	Child Health and Nutrition Research
CHNRI:	Child Health and Nutrition Research Initiative
COHRED:	Council for Health Research and Development
DALY:	Disability-Adjusted Life Years
ENHR:	Essential National Health Research
GFHR:	Global Forum for Health Research
GIS:	Geographical Information System
HIV:	Human Immunodeficiency Virus
IMCI:	Integrated Management of Childhood Illness
MTCT:	Mother-To-Child Transmission of HIV
NGO:	Non-Governmental Organisation
ORS:	Oral Rehydration Salts
ORT:	Oral Rehydration Therapy
R-ORS:	Reduced osmolarity Oral Rehydration Salts solution
TB:	Tuberculosis
TDR:	Special Programme for Research and Training in Tropical Diseases
UN:	United Nations
UNDP:	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID:	United States Agency for International Development
WHO:	World Health Organization

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