EVALUATION OF THE IMPLEMENTATION OF HEALTH INTERVENTIONS AND THEIR IMPACT ON CHILD SURVIVAL IN TANZANIA

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Summary

It is widely accepted that achieving the highest and most equitable levels of health of populations through the most rational use of resources is the ultimate goal of national and international policymakers, public health officials and health professionals at large. However, doing this depends upon understanding the burden of disease, its distribution and causes in a given population and the effectiveness of different preventive, curative and palliative interventions that can reduce these burdens.

Demand for comparable cause-specific mortality data of high quality has grown due to increased pressure to meet ambitious short-term goals and targets set by the international donor community. Robust data are urgently needed to assist policy makers and health planners in setting intervention priorities, the allocation of resources, and the analysis of the equity and effectiveness of health interventions and systems.

The counting of births, deaths by age and sex, and documentation of causes of death is the norm for all routine vital registration systems implemented throughout the developed world. But in most developing countries, routine empirical data on population burden of disease are usually missing, or at best, grossly incomplete due to the lack of systems and resources to support their collection and documentation.

Mortality surveillance systems or surveys using verbal autopsy have the potential to provide invaluable data for informing the health system on the burden of disease, and for monitoring and evaluating of the impact of different health and health system interventions as they are being implemented. The sentinel surveillance platform that includes the Ifakara, Rufiji and AMMP Demographic Surveillance System sites in Tanzania offers a great opportunity to examine this potential.

The goal of this thesis was to explore a variety of innovative approaches to evaluating the implementation of health interventions and their impact on child survival in Tanzania.

This was pursued by analyzing the burden of disease for the period from 2000-2002 in the rural areas of Kilombero and Ulanga district in which a population of approximately 65,000 people is under continuous surveillance. I also examined health systems access for pregnant women and children younger than five in a rural area in Rufiji district by combining demographic surveillance systems with geographic information systems in a population of approximately 70,000 people in 12,000 households. Using a sentinel surveillance platform in a non-randomised "plausibility" design across the four districts of Kilombero, Ulanga, Morogoro Rural and Rufiji, the thesis also examines the child survival effectiveness, cost and impact of the integrated management of childhood illness (IMCI).

The main findings were:

- 42% of mortality in children younger than five years of age occurred due to conditions that are well known and for which Districts have the technology to prevent or treat.
- Spatial access to health care by children and pregnant women in Rufiji District was similar with an average travel time to a health facility of less than 1 hour.
- Facility based IMCI improved quality of care and was associated with a 13% reduction in mortality in children younger than five in intervention districts.
- The costs of child health care in districts implementing IMCI was similar to or lower than those in comparison districts.
- Introduction of IMCI led to improvements in child health that did not occur at the expense of equity.
- Changes in the programmatic delivery strategy of vitamin A supplementation improved coverage in Tanzania and has been sustained for more than three years.

- Delivery of high dose of vitamin A supplementation in mothers and children less than six months of age was well tolerated, but did not confer any important absolute effect on morbidity.

Experience gained from the studies documented in this work can contribute to the body of knowledge on the estimation of causes of death, inform future evaluations, and help to shape child health policy in Tanzania and other similar settings. The need for robust, representative routine demographic and health statistics is critical for the monitoring and evaluation of health interventions and systems. The model recently proposed by the Health Metrics Network provides this opportunity for more countries. Investing in the strengthening of health systems, including health information sub-systems such as sentinel surveillance, is necessary if strategies like IMCI are to be prioritized and implemented effectively. IMCI implementation was successful in Tanzania because of the strong health system support that existed. Although results form the DHS 2004 and from sentinel surveillance indicate dramatic improvements, overall, infant and under five mortality rates are still unacceptably high. Achieving the Millennium Development Goal of reducing the 1990 level of child mortality by two-thirds by 2015 will require intensified efforts and new interventions to prevent deaths from major killers of children in Tanzania which include malaria, pneumonia, diarrhoea, under nutrition and perinatal causes. Wider and more equitable coverage is required, especially for the districts that are still lagging behind in the implementation.

This thesis shows that important progress can be made with a practical mix of population based evidence used in a health systems approach.

Zusammenfassung

Es gilt als unbestritten, dass das Streben nach dem bestmöglichen Gesundheitszustand der Bevölkerung bei gleichzeitig rationalem Ressourceneinsatz und höchster Verteilungsgerechtigkeit das ultimative Ziel von nationalen und Gesundheitspolitikern, von Gesundheitsbeamten und von Gesundheitsfachleuten im Allgemeinen darstellt. Der Erfolg solcher Bemühungen hängt vom Verständnis von der Krankheitslasten sowie ihrer Ursachen und ihrer Verbreitung innerhalb einer gegebenen Bevölkerung sowie von der Wirksamkeit der verschiedenen präventiven, kurativen und palliativen Behandlungen ab.

Die ehrgeizigen und kurzfristigen Ziele und Vorgaben der internationalen Gebergemeinschaft haben die Nachfrage nach vergleichbaren, qualitativ hochstehenden und ursachenspezifischen Daten zur Sterblichkeit wachsen lassen. Verlässliche Daten werden dringend benötigt, um Entscheidungsträger und Planer im Gesundheitsbereich bei der Definition von Massnahmenprioritäten, beim Ressourceneinsatz und bei der Analyse der Verteilungsgerechtigkeit und Wirksamkeit von Gesundheitsmassnahmen und -systemen zu unterstützen.

In den entwickelten Ländern ist die statistische Erfassung der Geburten und Todesfälle, aufgeschlüsselt nach Alter und Geschlecht, und die Dokumentation der Todesursachen in der Vitalstatistik Standard. In den meisten Entwicklungsländern hingegen fehlen solche empirischen Routinedaten über die Krankheitslasten in der Bevölkerung, oder sie sind, im besten Falle, sehr unvollständig, da Systeme zur Erfassung und Dokumentation solcher Daten inexistent sind und dafür auch keine Mittel bereitstehen.

Mortalitätsüberwachungssysteme (Demographic Surveillance Systems, DSS) oder andere Beobachtungssysteme, die auf Befragungen basieren, können den Gesundheitssystemen unschätzbare Daten über die Krankheitslast der

Bevölkerung liefern. Diese Daten sind ausserordentlich wertvoll für die Beobachtung und Beurteilung der Wirksamkeit der unterschiedlichen, die Gesundheit oder die Gesundheitssysteme betreffenden Massnahmen – und zwar bereits während ihrer Implementierung. Die Sentinel Surveillance Platform, die Resultate aus verschiedenen Regionen Tansanias, in denen Daten durch Demographic Surveillance Systems DSS gewonnen werden (Ifakara, Rufiji und AMMP), zusammenfasst, bietet die unschätzbare Möglichkeit, dieses Potential zu überprüfen.

Das Ziel dieser Dissertation war es, verschiedene innovative Ansätze zur Evaluation der Implementierung von Gesundheitsinterventionen und ihrer Auswirkungen auf die Überlebenschancen von Kindern in Tansania zu analysieren.

Dieses Ziel wurde durch eine Analyse der Krankheitslast während der Jahre von 2000 bis 2002 in den ländlichen Regionen des Kilombero- und des Ulangadistrikts verfolgt, in denen annähernd 65'000 Einwohnerinnen und Einwohner unter ständiger demographischer Beobachtung stehen. Ich habe ausserdem den Zugang zu Gesundheitsdiensten für schwangere Frauen und Kinder unter fünf Jahren in den ländlichen Gegenden des Rufiji Distrikts untersucht (ca. 70'000 Einwohnerinnen und Einwohner in 12'000 Haushalten), indem ich Daten aus DSS mit Daten aus geographischen Informationssystemen (GIS) kombiniert habe. Die Arbeit untersucht ausserdem die Überlebenschancen von Kindern („child survival effectiveness“) sowie Kosten und Nutzen von Integrated Management of Childhood Illness (IMCI) auf der Grundlage der Sentinel Surveillance Platform in den vier Distrikten Kilombero, Ulanga, Morogoro Rural und Rufiji im Rahmen eines nicht-zufälligen Plausibilitätsansatzes („non-randomised plausibility design“).

Die Hauptergebnisse lassen sich so zusammenfassen:

- 42% der Sterblichkeit bei Kindern unter fünf Jahren lässt sich bekannten Ursachen zuschreiben, für die Präventions- und Behandlungsmöglichkeiten im Distrikt vorhanden sind.
- Im Rufiji-Distrikt ist der Zugang zu Gesundheitsdiensten für Kinder und schwangere Frauen ähnlich: durchschnittlich beträgt die Distanz zur nächsten Gesundheitseinrichtung weniger als eine Stunde.
- In jenen Distrikten, in denen IMCI zur Anwendung kommt, verbesserte sich durch das in Gesundheitseinrichtungen basierte IMCI die Behandlungsqualität und reduzierte sich die Sterblichkeit bei Kindern unter fünf Jahren um 13%.
- Die Kosten für die Gesundheitsfürsorge bei Kindern in Distrikten mit IMCI waren gleich hoch oder fielen geringer aus als in den Vergleichsdistrikten.
- Die Einführung von IMCI führte zu einer Verbesserung der Gesundheit von Kindern ohne negative Folgen für die Verteilungsgerechtigkeit.
- Veränderungen in der Verteilstrategie von Vitamin-A-Beigaben haben deren Verfügbarkeit in Tansania nachhaltig verbessert, sie konnte über mehr als drei Jahre aufrechterhalten werden.
- Die Abgabe von hohen Dosen von Vitamin A-Beigaben an Mütter und Kinder unter sechs Monaten wurde gut aufgenommen, ohne allerdings einen wichtigen absoluten Effekt auf die Sterblichkeit zu zeitigen.

Die Erkenntnisse aus den Studien in dieser Arbeit können dazu beitragen, das Wissen um mögliche Todesursachen zu vermehren und künftige Evaluationen zu verbessern. Sie helfen bei der Gestaltung einer Gesundheitspolitik für Kinder in Tansania und in anderen Ländern in vergleichbarer Situation. Der Bedarf nach verlässlichen, repräsentativen und routinemässig erhobenen demographischen und Gesundheitsstatistiken ist zentral für die Beobachtung und Evaluation von Massnahmen und Systemen im Gesundheitsbereich. Das jüngst vom internationalen Health Metrics Network vorgeschlagene Modell bietet diese Möglichkeit für zahlreiche Länder. Investitionen in die Stärkung von Gesundheitssystemen, und dazu gehören auch Gesundheitsinformationssysteme wie Sentinel Surveillance, sind notwendig,

sollen Strategien wie IMCI priorisiert und wirksam implementiert werden. Die Einführung von IMCI in Tansania war deshalb erfolgreich, weil das Gesundheitssystem diese Strategie sehr unterstützt hat.

Obwohl die Ergebnisse des Demographic and Health Survey 2004 und andere Erhebungen dramatische Verbesserungen aufzeigen, sind die Sterblichkeitsraten für Säuglinge und Kinder unter fünf Jahren noch immer inakzeptabel hoch. Soll das im Millennium Development Goal formulierte Teilziel, die Kindersterblichkeitsrate von 1990 bis ins Jahr 2015 um zwei Drittel zu reduzieren, erreicht werden, so sind in Tansania verstärkte Anstrengungen und neue Massnahmen erforderlich, um die den fünf Haupttodesursachen zuzuschreibenden Todesfälle zu verhindern (Malaria, Lungenentzündung, Diarrhoe, Unterernährung und perinatale Ursachen). Notwendig ist eine breitere und gerechtere Abdeckung, gerade auch für jene Distrikte, die bei der Implementierung von Massnahmen immer noch zurückbleiben.

Die Arbeit zeigt auf, dass durch eine Kombination bevölkerungsbasierter Ergebnisse mit einem Gesundheitssystemfokus wichtige Fortschritte erzielt werden können.

PART I: BACKGROUND

INTRODUCTION

1.1 Millennium Development Goals

In September 2000, the world's largest gathering of Heads of State at the United Nations Millennium Summit met to resolve action on the most pressing problems of humanity (United Nations 2001). A declaration, endorsed by 189 countries, was then translated into a roadmap setting out goals to be reached by 2015. This declaration is what has become to known as the eight Millennium Development Goals (MDGs) (Millennium Assembly of the United Nations 2000). The MDGs build on agreements made at United Nations conferences in the 1990s, represent commitments to reduce poverty and hunger, and to tackle ill-health, gender inequality, lack of education, lack of access to clean water and environmental degradation.

Millennium Development Goals

1. Eradicate poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, TB, malaria and other diseases
7. Ensure environmental sustainable
8. Develop global partnership for development

Improving health received considerable prominence in the MDGs. Three out of eight goals, eight of the 16 targets and 18 of the 48 indicators relate directly to health: maternal and perinatal conditions, diseases affecting infants and children and major communicable diseases. Targets for each goal were developed to help assess and monitor progress. The three health related goals are MDG 4,5 and 6. MDG-4 specifically calls for a reduction in under-five mortality by two-thirds, MDG-5 sets a target to reduced maternal mortality by three quarters and MGD-6 pledges to combat HIV/AIDS, malaria and other diseases over 25 years between 1990 and 2015.

Since their adoption, these time-bound goals have been criticized as over-ambitious, immeasurable and therefore inadequate to guide progress (Attaran 2005), and too biased towards communicable diseases, ignoring the increasing non-communicable diseases epidemic in developing countries (WHO 2005b;WHO 2005c). Despite this, the goals have been widely accepted as a framework to stimulate increased efforts to achieve social and economic development.

In 2005, world leaders gathered at the UN to review progress and reaffirm their commitment (United Nations 2005) . While some countries have made impressive gains, many more are falling behind. Progress is particularly slow in many countries of sub-Saharan Africa (Sachs & McArthur 2005). The reasons are many, including lack of preventive care and treatment, fragile health systems, and socio-economic stagnation due to conflict, instability and AIDS. Cambodia and Iraq are countries in other regions where conflict has slowed or even reversed progress. Countries like Bangladesh and Tanzania, have made important progress recently, even then though their economies are very poor. Bangladesh has reduced maternal mortality from 514 in 1989 to 382/100,000 live births in 2001 (AbouZahr & Wardlaw 2001). Tanzania has reduced infant mortality from 100 in 1995-1999 to 68/1000 live births in 2004 respectively (Tanzania National Bureau of Statistics & Macro International Inc.Calverton 2005).

In less than 10 years, in 2015, governments of the world will meet again to assess whether the world's community has achieved these mostly widely ratified and loudly trumpeted set of development goals ever signed onto by every country in the world (United Nations 2001).

1.2 Child survival

The Child Survival Revolution was launched in 1982 by the late Executive Director of UNICEF Dr. James P. Grant (United Nations International Children's Emergency Fund) (UNICEF 1996). Major international organizations that were active in child health, regional and national leaders

pledged their support to the initiative. In many countries, substantial progress in reducing child mortality was made in the 15 years that followed. Globally, under five mortality on average fell by 21% from 117 in 1980 to 93 per 1000 live births in 1990 (UNICEF 2001).

Unfortunately, during the 1990s, this momentum was lost, and the trends that were observed earlier either stagnated or even reversed (Ahmad, Lopez, & Inoue 2000;Bryce et al. 2003b;Bryce et al. 2005). Estimates show that more than 10 million children younger than five years continue to die each year (Ahmad, Lopez, & Inoue 2000), a majority of whom come from low and middle-income countries. They continue to bear the brunt of almost one third of the total burden of disease and worse still, 40% of all under five deaths occur in newborn babies (Lawn, Cousens, & Zupan 2005a). Two thirds of all under five deaths could be prevented by interventions that are available and affordable in low income countries today (Jones et al. 2003b). Although HIV/AIDS rates are high, it's emergence has yet to become a major threat to child survival in Africa (Walker, Schwartlander, & Bryce 2002).

Two series of *The Lancet* – Child survival (Black, Morris, & Bryce 2003;Bryce et al. 2003a;Claeson et al. 2003;Jones et al. 2003a;Victora et al. 2003) and Neonatal survival (Darmstadt et al. 2005;Knippenberg et al. 2005;Lawn, Cousens, & Zupan 2005b;Martines et al. 2005) have helped to focus attention and reinvigorate the efforts to reduce child and newborn deaths and hence to achieve MDG-4. More published reports on progress in child survival are being published annually by country (Adjuik et al. 2006;Ahmad, Lopez, & Inoue 2000;WHO 2005a), and trends are extrapolated (Child Mortality Coordination Group 2006) to see whether the countries are likely to achieve the goals or not. Public commitments to investing more in reducing child deaths have been made by international community leaders from WHO and UNICEF (Mason 2005). More efforts have now been put into forming global and synergistic alliances with one and the same aim of improving maternal, newborn and child health.

1.3 Global Health Initiatives

The advent of the new millennium has brought a different perspective on global health aid. There is more money now than ever before directed towards improving health especially in poor countries. More than a dozen massive new efforts have been created, including the Global Fund to Fight AIDS, Tuberculosis and Malaria which has committed more than $4.9 (The Global Fund 2006) billion to 131 countries, the US President's Emergency Plan for HIV/AIDS Relief (PEPFAR) that has pledged $15 billion for five years to selected countries (US Department of State Bureau of Public Affairs 2003), Global Alliance for Vaccine and Immunization with $3 billion is assisting 72 countries to vaccinate more that 100 million children, potentially sparing more than 1 million from premature death due to *Haemophilus influenzae* B, pertussis, hepatitis B, measles and other disease. The World Bank has also pledged to implement global antimalaria scheme worth up to $1 billion over 5 years (World Bank 2005).

Some of the major donors supporting such partnerships and global health initiatives come outside the health care industry and many Global Health Initiatives are public:private partnerships. Together they have committed more than $35 billion to fight diseases of the world's poor (Cohen 2006). At the forefront of these efforts is the Bill and Melinda Gates Foundation, which since 1999 has pledged approximately $6 billion (Bill and Melinda Gates Foundation 2006), roughly the budget of the World Health Organization (WHO) during the same time to fight HIV/AIDS, malaria, tuberculosis and other long under funded diseases.

Despite the mobilization, the Macroeconomics and Health Commission estimates on the resources required to meet global public health needs are unfortunately still short of the requirements. An estimated $30 billion is needed in aid per year ($27 billion by 2007, rising to $38 billion by 2015) (Sachs 2001). Current health-related annual transfers are in the order of magnitude of about $8 billion. There are also concerns about the lack of global health architecture (Godal 2005). There is considerable confusion on how these new entities fit together, as well as how they mesh with traditional

agencies such as WHO, United Nation's Children's Fund (UNICEF) and the World Bank. The UNAIDS report (UNAIDS 2005) and the Paris declaration (OECD-DAC Development Cooperation 2005) together call for increased efforts in harmonisation, alignment and managing aid for results with a set of actions and indicators that are easy to monitor.

1.4 Health Sector Reforms in Tanzania

Health sector reforms are a dynamic process; many countries have gone through them and will continue doing so if their health systems are to respond to the changing needs and the environment. Tanzania like most developing nations is no exception. The history of health sector reforms in Tanzania shows four marked waves dating back to pre-independence 1884-1961, post-independence 1962-1972, 1973-1983 and pre-pluralism 1984-1994.

During the first wave where Tanzania was subject to German colonial rule, some form of health services were introduced mainly along the coastal areas of Tanga, Pangani, Bagamoyo, Dar es Salaam and Kilwa and in sisal plantations (GTZ 2001). Further expansion inland to Tabora, Mwanza and Bukoba was mainly driven by economic and administrative reasons. At the same time missionaries also established some medical services where they settled especially in the highland areas. However after World War I, the British took over the surrendered or abandoned hospitals and devoted time to reconstruct and establish the civil medical services that formed the basis of the current health services.

The second wave of health sector reforms started with post-colonial independence, 1962-1972. The new government declared war on three major enemies, namely disease, ignorance and poverty (Jonsson 1986). During this time there was more decentralization to local government in the districts and emphasis on health services provision to rural areas. Local governments were mandated to collect tax revenue and run health services (Government of Tanganyika 1962). To honor its political commitment to eradicating diseases, the government commissioned an appraisal of the health system and went on

to implement recommendations that included construction of more health facilities and integrating services run by the local governments to those under the central government (Titmus et al. 1963). This wave was also marked by the Arusha Declaration 1967, which emphasized self reliance as a strategy to achieve social development including health.

The third wave of health sector reforms was from 1973 to 1983. Problems of inadequate resources and finances for rural areas were challenges that were still facing the government. Decentralization had given power to local authorities for provision and management of health was abolished during this period. The central government took over all the functions of local government including all health facilities and personnel. This led to an increase in government expenditure to purchase drug supplies, equipment and pay salaries. Less and less funds became available for the health sector as a result of countrywide drought and the war in Uganda. The economic situation became worse since independence and some structural adjustments measures were imposed (Peabody 1996). These included cutting public spending for the social sector including health.

The fourth wave came when the economic turmoil was still persisting. Government spending on health declined substantially Soon it was realized that free health care for all was no longer a feasible endeavour and therefore user fees or cost sharing were introduced to increase financial resources for health care provision. In this wave, the government reverted back to decentralization. The move was meant to increase efficiency, community participation and management responsibility.

In 1993, the central government approved the Health Sector Reform Act and this was the beginning of the current health sector reforms. This was also the same year which the World Bank launched the World Development Report: Investing in Health (World Bank 1993) that was a clear reversal of its previous policies of restricted financing of public programs. It was realized that increased investment in health was a key element to economic development. It prescribed that such investment should be based on evidence that would

target and focus cost-effective interventions on the local "burden of disease" that exists in a particular ecosystem. In 1999, the National Package of Essential Health Interventions was defined by the MOH as an initial step towards implementing the Bank's policies.

1.5 National Package of Essential Health Interventions

The National Package of Essential Health Interventions is a catalogue of both public health measures and clinical services which are supposed to be highly cost-effective and help to resolve major health problems. The guiding principal for selecting which services to include in the package are; the magnitude of the burden caused by a particular disease and the cost effectiveness of interventions that deal with the problem (Bobadilla et al. 1994).

The Tanzania Package of Essential Health Interventions addresses related conditions that were clustered together into five groups. It was not designed in the spirit of a minimum package but rather on an inclusive consensus. The package includes, reproductive and child health, communicable disease control, non-communicable diseases control, treatment of other common disease of local priorities within districts and community health promotion and disease prevention. Not all interventions found in the package were chosen by virtue of their cost-effectiveness partially because of lack of adequate knowledge and health information systems at that time, and also due to stakeholders working to serve their interests with interventions that were more inline with their own ongoing activities.

At least nine sources of information or systems are now present to help in the process of redesigning a package in a more rigorous way than before. These included population-based sources such as the decennial census, the National Demographic and Health Surveys (DHS), and the demographic surveillance systems run by various projects of the Tanzania Essential Health Interventions Project (TEHIP), Adult Morbidity and Mortality Project (AMMP), and KISESA at Morogoro, Hai, Dar es Salaam, Kilombero/Ulanga, Rufiji, and Magu, as well as health facility-based sources such as the Health

Management Information Systems (HMIS), Integrated Disease Surveillance (IDS), Essential Drug Programme (EDP) and the Expanded Program on Immunization (EPI),.

1.6 Evidence-based planning

Information demand and use has changed considerably in all levels in Tanzania. The need for reliable, current and longitudinal indicators of demographic, health conditions and poverty are rapidly increasing. Health sector reforms, sector wide approaches and global health initiatives such as the Global Fund to Fight AIDS, TB and Malaria (GFATM) come with major obligations to monitor and evaluate progress and impact to meet demands of results and accountability. Simultaneous with these demands, decentralization of responsibilities for local planning has encouraged the spread of evidence based approaches to policy and practice.

A number of both multi- and bilateral donors and programmes have supported Tanzania in achieving its goal of using evidence in planning. But, the government has also been on the forefront is setting up the pace of reforms and shaping the process. Under the Health Sector Reform program, Tanzania had to initiate several strategies towards the improvement of the health services which had deteriorated to the extent of collapse. Among the changes instituted by the government were; the establishment of cost-sharing arrangements in public hospitals through user fees, introduction of health insurance in the form of Community Health Funds (CHF) at district/ local levels, and regulatory reforms whereby the private sector was also allowed to operate to supplement government efforts.

On the other side, the Ministry of Health's reform partners such as AMMP and TEHIP and Ifakara Health Research and Development Center (IHRDC) who are linked to the demographic surveillance sites for health and poverty have provided burden of disease information to the districts plus other simple to use costing and management tools that have enabled the districts to make rational spending of their funds.

Data generated from the demographic surveillance sites in Rufiji and Morogoro Rural was instrumental in assisting the districts to choose and implement a number of of new interventions such as Insecticide Treated Nets for malaria, and Vitamin A Supplementation (VAS) and the Integrated Management of Childhood Illness (IMCI) for under-fives. In this thesis we examine the IMCI and VAS, hence some introductory background is provided here.

1.7 Integrated Management of Childhood Illness (IMCI)

The Integrated Management of Childhood Illness (IMCI) is strategy for improving children's health and development through the combined delivery of essential child health interventions (WHO 1999). It began with a set of case management guidelines for sick children seen at first level health facilities. Later, the strategy expanded to include guidelines for case management and preventive interventions against the leading causes of childhood mortality; pneumonia, diarrhoea, malaria, measles and malnutrition. A training course was later organized by WHO and UNICEF in 1996 targeting health workers at first level facilities to make correct decisions in the management of sick children (Gove 1997). The guidelines were further refined and tested through research and field testing in several countries including, The Gambia (Weber et al. 1997), Ethiopia (Simoes et al. 1997), Kenya (Perkins et al. 1997) and Tanzania (WHO Division of Child Health and Development & WHO Regional Office for Africa 1997).

A broader strategy followed later which included both preventive and curative interventions for promoting child health development. The three components of these interventions included: 1) improving the health systems to support IMCI; 2) improving the skills of health workers; and 3) improving family and community practices.

Typically, IMCI implementation in a country goes through three phases. In the first phase or introduction, for many countries IMCI provides them with an opportunity to review child health policies and recognize their services and

interventions. The main objective is to ensure that key personnel in the ministry of health understand the IMCI strategy and its implications as the basis to go ahead with the planning and preparation. The second phase is for early implementation, in which the country adapts the generic IMCI guidelines to ensure that the materials are consistent with the epidemiological situation and with the treatment guidelines and other policies and that it is feasible to implement the guidelines through the health system. At this stage IMCI is also introduced in a limited number of areas and the experience carefully documented and analyzed. The third phase is expansion to more areas based on experience gathered from the second phase.

By the end of 2002, more than 80 countries had adopted IMCI as part of their national child health policy. A need to evaluate the strategy as a holistic approach to the delivery of these interventions was necessary. 5 countries were selected to participate in the evaluation as a result of a worldwide review of 12 possible sites based on the application of standard set of criteria (WHO 2002).

1.8 Multi-Country Evaluation of IMCI (MCE-IMCI)

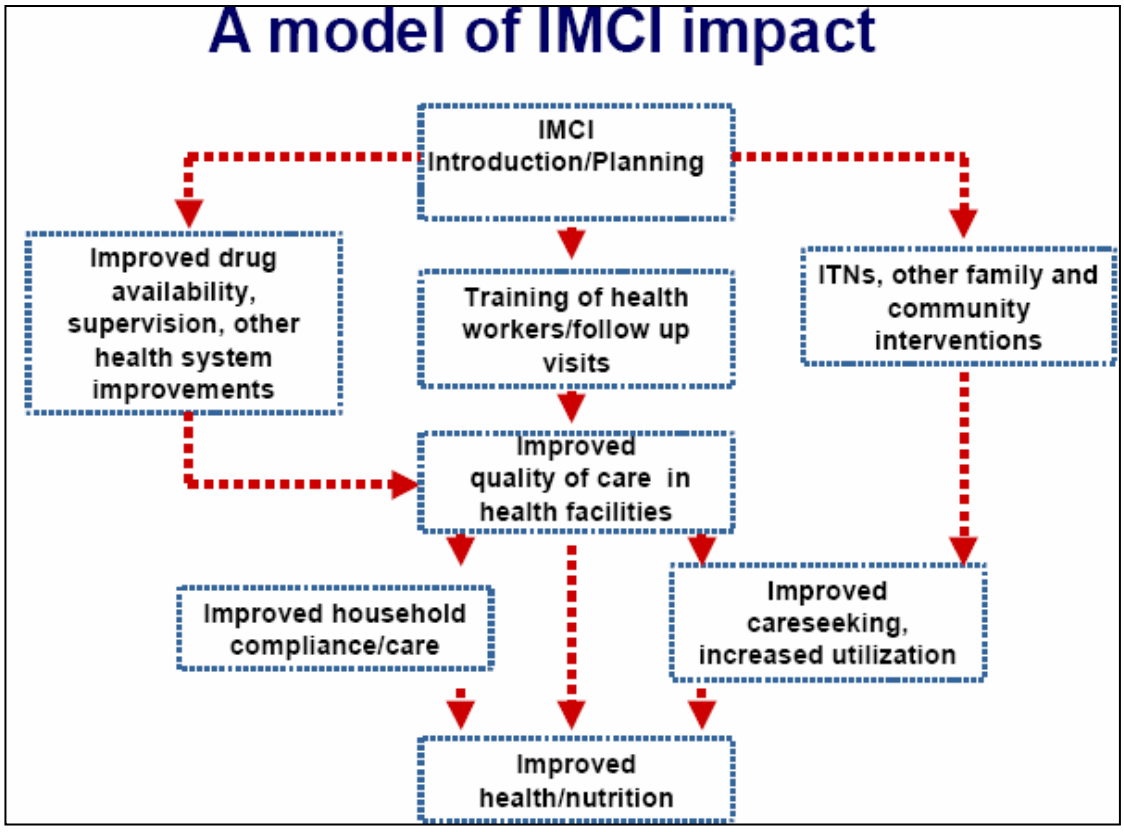
In 1998, the Multi-Country Evaluation of IMCI cost, effectiveness and impact (MCE-IMCI) was launched in five countries: Bangladesh, Brazil, Peru, Tanzania and Uganda (Bryce et al. 2004). The different countries were selected to provide a broad variability of contextual factors, including different health systems, mortality levels and patterns, social and economic characteristics. The evaluation is coordinated by the Department of Child and Adolescent Health (CAH) of the World Health Organization, with support from Bill and Melinda Gates Foundation.

The objective of IMCI-MCE is to evaluate the effectiveness, cost and impact of IMCI on child health and survival. A major aim is to help determine the best ways of delivering integrated child health care, especially to poor children and families. Its outcome is expected to contribute to the improved delivery of effective interventions for child survival, health and development at high and

sustained levels of coverage. The MCE team then developed an impact model describing how the introduction of IMCI might to reduce child mortality and improve nutrition.

Studies of the effectiveness, cost and impact of the IMCI strategy were carried out in 5 countries using a range of study designs from an ecological study in Peru to a randomized controlled trial in Bangladesh (Habicht, Victora, & Vaughan 1999). Four countries, Brazil (Amaral et al. 2004), Uganda (Pariyo et al. 2005), Peru (Huicho et al. 2005) and Tanzania (Armstrong Schellenberg et al. 2004) have completed their evaluations. The Bangladesh study is expected to complete in 2007 (el Arifeen et al. 2004).

IMCI implementation in Tanzania started in late 1996 and was preceded by the global field test of the IMCI field materials for first line health workers in



Arusha in 1995 (Gove 1997). In 1998, Tanzania also became the first country to introduce IMCI in pre-service training institutions. The presence of reform partners including Adult Morbidity and Mortality Project (AMMP) and Tanzania Essential Health Interventions Project (TEHIP) working with the Morogoro

Rural and Rufiji Districts Council Health Management Teams (CHMT) facilitated these districts to be early users of the strategy. The two districts were part of the MCE study which evaluated the improved case management and system support components of IMCI strategy. The third component, community IMCI was not implemented at the time of the study.

1.9 IMCI implementation in Rufiji

The introduction and expansion of IMCI implementation in Rufiji district was facilitated by the prominence of IMCI addressable causes in the burden of disease that dramatized the need to prioritize IMCI. The burden of disease profile in the first few years before the sentinel site in Rufiji was ready to provide cause-specific mortality data came from the Morogoro Rural district sentinel which had already been running for more than five years (Tanzania Essential Health Interventions Project & Ministry of Health 2002). The district had also the privilege of simulated Sector Wide Approach (SWAp) health "basket funding" from TEHIP since 1997. In this funding they had less than $1 USD per capita of additional incremental funding at their disposal that they could use for any cost-effective health system change that would improve the ability to address a substantial part of disease burden.

During the first quarter of 1997 a total of six district level Trainer of Trainers (TOTs) attended an eleven day IMCI Training of Trainers course that also included four days of facilitation skills. With the simulated basket funds, the districts were able to finance the training and procure IMCI supplementary drugs and equipment from the Medical Stores Department (MSD) on a credit basis.

Eight training courses for frontline providers were conducted between 1997 and 2001. A total of 90 health workers of different cadres had been trained during this period. These included assistant clinical officers (ACOs), clinical officers (COs), nursing officers, maternal and child health aides, nurse mid-wives and nursing assistants. By the end of 1999, the CHMT had trained health workers to the level of 1 for every 300 children. Three special courses

for non-clinicians lasting 16 days each were conducted 1999 and 2000 in Rufiji because the district had a shortage of medically qualified health personnel. The target was nurse assistants who are mainly in charge of health facilities and also managing children younger than five years (Mbuya et al. 2003).

Potential impact of IMCI depends on coverage. For the MCE, one definition of IMCI coverage was to have 60% or more of health workers who normally attend children younger than five years in a health facility IMCI trained, followed-up and supported by the system. The MCE target for this indicator was that 80% of all health facilities in the said district meet this criterion. This was achieved in the first quarter of 2000.

1.10 Vitamin A Supplementation

Vitamin A Supplementation (VAS) is one of the most simple, easy to implement and highly cost effective intervention that is available in public health (World Bank 1993). A dose of vitamin A is estimated at $0.02 and supplementation programmes are being implemented in more than 70 countries worldwide. In areas where vitamin A deficiency (VAD) is problem of public health importance (WHO 1998), vitamin A supplements are recommended as prophylaxis and as treatment to at-risk groups and sick individuals respectively. These are children 6-59 months and post-partum women. Evaluation from efficacy programs have shown that given high dose supplements to at least 80% of the population 6-59 months of age at 4-5months intervals is likely to have an impact on mortality. A meta-analysis of eight randomized controlled trials (Beaton et al. 1993) showed an average reduction of 23% (95% CI:12-32%) in child mortality from diverse populations that were presumably free of HIV infection (Fawzi et al. 1993). Randomized control trials in HIV infected populations have also been reported elsewhere (Fawzi et al. 1999;Humphrey et al. 2006;Malaba et al. 2005;Semba et al. 2005).

The effect of vitamin A supplementation on maternal and neonatal health is of extreme importance. However, evidence from different studies on vitamin A supplementation during pregnancy (van den Broek et al. 2002) and in children less than 6 month have been conflicting. A large dose of vitamin A given to neonates of normal birth weight in Indonesia was associated with a reduction in mortality (Humphrey et al. 1996). In a similar trial in India, beneficial effects were found in infants of low birth weight (Rahmathullah et al. 2003). Vitamin A supplementation given in high doses to mothers at birth and children during their routine vaccination in a multi centre trial in Ghana, Peru and India (WHO/CHD Immunisation-Linked Vitamin A Supplementation Study Group 1998) found no evidence of an effect on infant mortality. A similar trial (chapter 9) in Tanzania by Idindili and colleagues (in preparation) found no effect on short term morbidity.

1.11 Vitamin A Supplementation in Tanzania

Vitamin A deficiency is a problem of public health importance in Tanzania, affecting mainly children and women of child-bearing age. The magnitude of the problem was first documented in a national prevalence survey (TFNC & Ministry of Health 1998) and revealed that 24% of children 6-71 months of age and 69% of lactating mothers had serum retinol levels below the recommended threshold of <0.70µmol/L and <1.05 µmol/L respectively (WHO 1998).

The first national programme to combat vitamin A deficiency (VAD) in was initiated in 1995, two years prior to the national survey. The efforts were mainly focused on supplementation as a short term measure and promotion of production of vitamin A rich foods as a long term solution. Nutritional education was given to further support these measures. In 1987 vitamin A capsules were incorporated into the Essential Drugs Program (EDP). This was confined to government-owned primary health care facilities and targeted therapeutically to children between 6-59 months suffering from xerophthalmia or diseases precipitating vitamin A Deficiency. Consequently, many young children at risk of VAD in Tanzanian communities were not reached.

Due to persistent problems of low coverage, vitamin A supplementation was integrated into routine services of the Expanded Programme on Immunization (EPI) in 1997. Under these services, vitamin A supplementation is given to all children under two years of age, at 9 months together with measles vaccination and at 15 and 21 months of age. Postpartum women are supplemented within four weeks after delivery. Vitamin A supplementation coverage under routine EPI has been increasing during measles immunization for nine month-old children (from 55% in 1999 to 82% in 2002), but has been very low for children 15 and 21 months of age. Most important, the distribution system excludes eligible children between two and five years of age. Coverage for postpartum women increased at a slow pace — from 45% in 1999 to 62%t in 2002.

Efforts to increase coverage led to the integration of VAS into sub-national measles immunization days in 30 of 113 districts of mainland Tanzania in 1999 and later in 52 districts in 2000. Coverage estimates from these campaigns were 94% and 99% respectively (Mugyabuso 2002). Experience gathered from these campaigns formed the basis of integration of VAS into the commemoration of the Day of the African Child in June and World AIDS day in December. VAS campaigns with the two events have been in effect since 2001. This thesis examines the performance of these two delivery approaches (Chapter x).

1.12 The Demographic Surveillance System platform

A demographic surveillance system (DSS) is a set of field and computing operations to handle the longitudinal follow-up of well defined entities or primary subjects (individuals, households, and residential units) and all related demographic and health outcomes within a clearly circumscribed geographic area. Unlike a cohort study, a DSS follows up the entire population of such a geographic area (INDEPTH Network 2002b)

The potential benefits of DSS systems are seen in their methodological strength of longitudinal follow-up of defined populations. The DSS provides a platform on which to base a range of health, social, economic and behavioural studies. These can take advantage of the sampling frame inherent in a DSS, whether at individual, household/compound or neighbourhood level. Studies may be inter-linked, exploit a mix of qualitative and quantitative methodologies, and address a diversity of formative, hypothesis generating, or hypothesis driven issues where findings can be related to underlying patterns of mortality, fertility and migration. The DSSs also provide rich information on trends in demographics, fertility, and health equity as well as empirical life tables of use to a great many analyses (INDEPTH Network 2002a;INDEPTH Network 2005),(cause-specific mortality monograph in preparation).

In the absence of vital registration in most parts of the developing world, DSS systems provide an information and evidence base for which decisions on targeting priority diseases and health conditions, allocating scarce financial and human resources, improving the efficiency of programs, and developing the skill-base of health workers can be made. Accurate age-specific mortality rates can be produced for the population under surveillance. In most of the sites, verbal autopsies are used to assign causes of death. The interviews are held with one of the adult relatives of the deceased (preferably a caretaker) well informed of the sequence of events leading up to the death (Anker 1996;Chandramohan et al. 1994;Snow et al. 1992).

Furthermore, the impact of interventions on mortality, non-fatal health outcomes, fertility and migration can be rigorously assessed. Interventions may be therapeutic (such as new drugs or vaccines), behavioural (e.g. sexual and reproductive behaviours) or involve changes to routine service delivery, health policy, or more extensive health reforms and development strategies. They may address the maximum impact of interventions under strictly controlled conditions (efficacy), or the impact of introducing new interventions into already existing services and systems (effectiveness).

A demographic surveillance system forms a framework for longitudinal population based research on poverty and equity. Routine data collected in a

DSS can be used to quantify equity in health in the area (Armstrong Schellenberg et al. 2003;INDEPTH Network 2005;Nathan et al. 2004) and also assist in assessing poverty monitoring strategies. DSS complements other information systems such as the Demographic and Health Surveys and Health Management Information System which are infrequent and facility based respectively.

These research environments provide unparalleled applied training opportunities for health and other professionals, with a particular emphasis on strengthening national capacities to seek, interpret and apply available information in the essential effort of evidence-based policy, practice and resource allocations.

Tanzania, like many countries in Sub Saharan Africa is faced with the dearth of reliable information for planning due to fragmentary routine data collection systems. However, over that last decade it has observed an increase in the number of DSS sites. These sites were chosen because certain intrinsic characteristics of interest to research communities. The locations in which some were established provided good opportunities to study the impact of interventions on AIDS and malaria. Others were selected because it was felt that they provided a range of living standards and conditions in the country that might be related to a health and demographic transition in Tanzania. Approximately 700,000 people participate in demographic surveillance in Tanzania, which is approximately 2 percent of the national population. This is roughly seven times the number participating in the National Household Budget Survey (Tanzania National Bureau of Statistics 2003) and almost twenty five times the sample of the most recent DHS (Tanzania National Bureau of Statistics & Macro International Inc.Calverton 2005). In addition to the Demographic and Health Surveys, the DSSs have also been integrated into the MKUKUTA Poverty Monitoring System Master Plan to assess progress in poverty reduction (Government of Tanzania 2005)

1.13 Poverty and equity evaluation in health

Over the last two decades, epidemiology literature has witnessed an explosion in questions relating socioeconomic patterning of health and disease. This has broadened our understanding of the interplay between socioeconomic status, health and disease. Along with these advances, data collection instruments and methods to evaluate inequities in health have been developed. Health inequities refer to health inequalities that are both unfair and unjust according to some theory social justice. They provide a picture of the gaps that exist between the rich and the poor, between and within countries.

Several methods have been suggested and are used extensively to group communities or individuals based on income, expenditure or wealth. In developing countries where income or expenditure data are rather hard to get let alone reliable, simpler methods that reflect the household or individual socio economic position have been used (Filmer & Pritchett 1999;Filmer & Pritchett 2001). The asset index pioneered by Filmer and colleagues is intended as a proxy for income and expenditure. It is based on simple weighted sum of the number of different items owned by the household. Within the DSS framework, it has been possible to develop tools and measure health inequities in small geographic areas, something that had not been done previously (INDEPTH Network 2005). The concentration indices and Lorenz curves have also become increasingly popular as measurement tools for equity and inequality in health and health care (Wagstaff 2002).

The World Bank's Health, Population and Nutrition Programme has supported analyses from data collected from over 50 developing countries by the USAID Macro International Demographic and Health Surveys. These analyses usually compare rural and urban populations, and quite often showing important health differentials between richer and poorer families in mortality, nutrition, care-seeking behaviour and coverage of interventions. However DSS sites find stark inequity gradients even in small areas with more homogeneous populations (INDEPTH Network 2005).

The next chapters of this thesis state the objectives and details of the different methodologies pursued to provide answers to the questions. The burden of disease and the need to have robust and comparable cause-specific mortality data is discussed in chapter 4. This is followed by the analysis on how spatial access to health care can assist in informing health planners on how best to plan the provision of health services (chapter 5). The following three chapters 6, 7 and 8 were evaluations within the framework of the Multi-Country Evaluation of the IMCI strategy. In chapter 6 we analysed the effectiveness and cost of facility based IMCI whereas in chapter 7 we analysed the change in programmatic delivery strategy of vitamin A supplementation on coverage. In Chapter 8 we analysed the impact of introducing large scale effectiveness studies inequalities in child health. Chapter 9 describes our experience in the evaluation of vitamin A supplementation in children less than six months in a randomized control trial and points to issues that need to be considered during such trials and in under programme conditions. A general discussion and conclusions are summarized in Chapter 10; key messages from the thesis are underscored and future research work is proposed.

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PART II: OBJECTIVES AND METHODS

CHAPTER 2: OBJECTIVES

2.1 Goal and general objective

The objective of this thesis is to explore innovative approaches to evaluating the implementation of health interventions and their impact on child survival in Tanzania.

2.2 General objectives

i. To describe the development of the longitudinal Demographic Surveillance System (DSS) as a platform for evaluating child survival, effectiveness of health interventions and health systems in Tanzania;
ii. To analyze the geographical mode of primary health care usage patterns at household level across the demographic surveillance area in Rufiji District.
iii. To analyze changes over time in equity of access (mosquito nets, vitamin A, health care, health care utilization) and outcome (nutritional status) through cross-sectional community surveys in 1999 and 2002, during and after the implementation of Integrated Management of Childhood Illnesses in southern Tanzania;
iv. To evaluate safety and efficacy of two vitamin A supplementation schedules in Tanzanian infants.

2.3 Objective 1

To describe the potential of longitudinal demographic surveillance system (DSS) as a platform for evaluating child survival, effectiveness of health interventions and health systems in Tanzania

3.2.1 Specific objectives

i. To describe the development of DSSs in Tanzania and their potential as a platform for evaluating health interventions and health system in Tanzania.
ii. To analyze and describe cause-specific mortality using verbal autopsy tool in Ifakara DSS

2.4 Objective 2

To analyze the geographic mode of primary health care usage patterns at household level across the demographic surveillance area in Rufiji District.

3.2.2 Specific objectives

i. Describe and summarize variations in travel times to health facilities
ii. Calculate Distance Usage Indices for health facilities within the DSS
iii. Predict travel time to health facilities for different modes of access

2.5 Objective 3

To analyze changes over time in equity of access (mosquito nets, vitamin A, health care, health care utilization) and outcome (nutritional status) through cross-sectional community surveys in 1999 and 2002, during and after the implementation of Integrated Management of Childhood Illnesses in southern Tanzania;

3.2.3 Specific objectives

i. To describe the overall coverage and measure inequalities for specific childhood health indicators including Vitamin A, mosquito nets, nutritional status, access to health care, and health care utilization through community surveys in the 1999 and 2002 among poor children in southern Tanzania during and after MCE-IMCI implementation.
ii. To measure intervention performance in specific child health indicators including vitamin A, mosquito nets, nutritional status, access to health care and health care utilization through community surveys in the 1999 and 2002 during and after MCE-IMCI implementation.
iii. To summarize the change in vitamin A supplementation coverage between 1999 and 2002, and describe the context of a change in policy.

2.6 Objective 4

To evaluate safety and efficacy of two vitamin A supplementation schedules in Tanzanian infants.

3.2.4 Specific objectives

i. Measure the effect of 400,000IU of vitamin A given in two divided doses of 200,00IU to mothers and 50,000IU of vitamin A given to infants concurrently with DPT/Polio immunizations, on vitamin A status of infant at 26 weeks of age.

ii. Compare the effect of such a regimen to the previously recommended dosage of 200,000IU of vitamin A given to mothers and 3 doses of 25,000IU given to infants concurrently with DPT/Polio immunizations.

iii. Measure the short term side effects of each of the two doses of 200,000IU given to mothers and of 50,000IU of vitamin A administered with each of the three DPT/Polio immunizations

CHAPTER 3: METHODS

3.1 Study Area

The study area for the health interventions discussed in this thesis is the four districts of Rufiji, Kilombero, Ulanga and Morogoro Rural. The districts have a total population of approximately 1.2m people, of whom 200,000 are less than five years of age (http://www.tanzania.gov/census). Rufiji and Kilombero are low lying, and much of the land is in the fertile flood plains of the Rufiji and Kilombero rivers. Morogoro Rural and Ulanga have mountainous areas as well as low-lying plains. There are two main rainy season, October-December and February-May. There are several ethnic groups, although Swahili, the national language is widely spoken.

The majority of the people are subsistence farmers. Farming areas are often set some distance from the family home to take advantage of periodically flooded alluvial soils. The dwellings are simple, comprising a mixture of huts with walls made of mud and wooden poles, with thatched or corrugated roofs, as well as conventional brick houses in the townships. Rural roads are generally unpaved, and transport can be difficult in the rainy season. The public health system has a network of hospitals, health centres, and dispensaries with approximately 3,300-7000 people served by each facility (ref). Rates of use of health facilities are high; routine reports from the Health Management Information System suggest 3.0 visits per child under five years old for curative care in 1999 (ref). Malaria and waterborne diseases, such as cholera and diarrhoea, are the major health problems in the area, according to both the health services and local people. Major causes of mortality include acute febrile illnesses (including malaria), acute lower-respiratory infections, tuberculosis, AIDS, and conditions arising during the perinatal period (Chapter 4). Seasonal food shortages are common, and a famine affected much of the country in early 1999.

Details of the designs and methodology used for the studies are described below.

3.2 Design Issues

3.2.5 Verbal autopsy

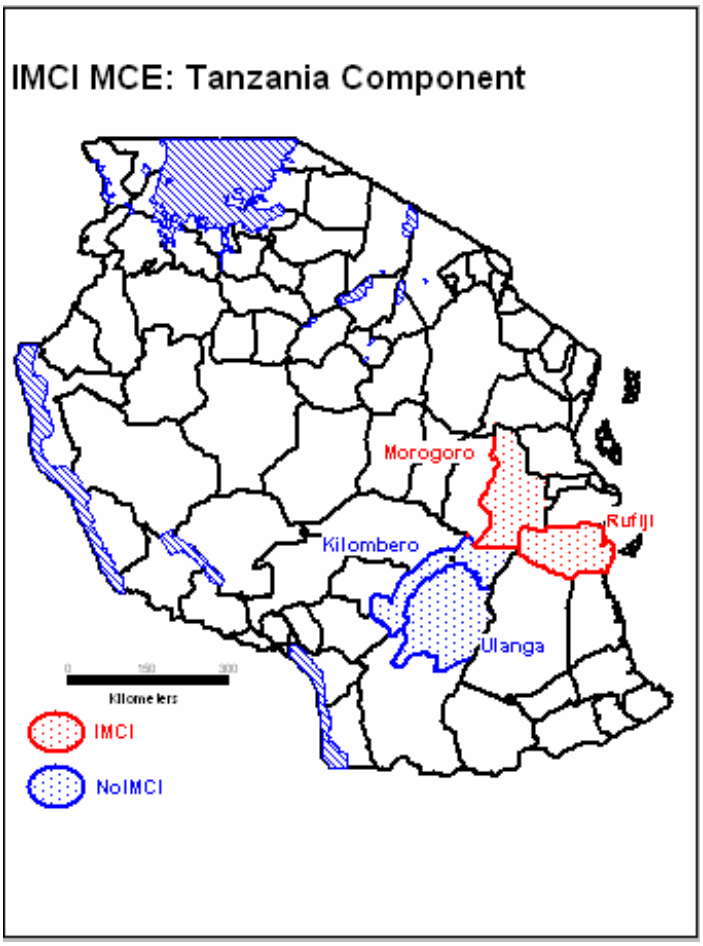
Assignment of causes of death using verbal autopsy (VA) is one of the sources of cause-specific mortality data in countries where vital registration systems are rudimentary or non-existent. In Tanzania, verbal autopsies for cause of death have been used to generate information to inform decision makers and planners at district level (de Savigny et al. 2001;Tanzania Essential Health Interventions Project & Ministry of Health 2002).

The process involves interviewing close relatives of the deceased through a structured questionnaire that details an account of the sequence of events and symptoms leading to death. Methods of arriving at possible cause of death include physicians review; predefined expert and data derived algorithms (Byass et al. 2006;Fantahun et al. 2006;Kahn et al. 1999;Quigley, Armstrong Schellenberg, & Snow 1996). In Ifakara DSS, physician panels review and code the forms using *The International Classification of Diseases and related health problems*, tenth revision (ICD10). For each death, two physicians independently assign an primary or underlying and an associated cause if present. The codes are then compared using a custom written programme in Foxpro 2.6. A final cause of death is reached if there was a consensus between the two coders. A third physician is asked to independently code the cause of death in the case of discordant results. Where there are three discordant codes, the cause is registered as "undetermined." So far, we have tried to attribute each death to a single cause although the coding form allows for multiple causes.

3.2.6 MCE-IMCI Tanzania study

The Multi Country Evaluation of IMCI Tanzania study adopted non-randomized control trial or "plausibility" design (Habicht, Victora, & Vaughan 1999;Victora, Habicht, & Bryce 2004) in which there is monitoring of process measures to improve the internal validity of the study and of contextual factors to check out whether any apparent effect of the intervention is due to other

factors. Two intervention (Morogoro Rural and Rufiji) and two comparison (Kilombero and Ulanga) districts were selected and compared for children's health and survival in 1999 and 2000. IMCI implementation in the intervention districts started in 1997-1998 and in 2002 for the comparison districts. The selection of comparison districts was based on several factors including, the existence of continuing demographic surveillance, had similar or lower mortality rates, existence of natural barrier between intervention and comparison areas and they had no immediate plans of implementing IMCI.



First, we carried out a cross-sectional survey in August 2000 in a sample of health facilities in the four districts and assessed quality of case management for illness in children, availability of drugs and vaccines and supervision of case management (Armstrong Schellenberg et al. 2004). Second, we conducted two household surveys in 1999 and 2002 in a probability sample from all the four districts to assess indicators of children's health (Armstrong Schellenberg et al. 2003;Masanja et al. 2005). Third, we tracked mortality through demographic surveillance throughout the study, with a particular emphasis on a pre-defined 2- year period from mid 2000, by which time IMCI implementation was thought to have reached sufficiently long period for an effect on survival to be measurable. Four, we documented information on contextual factors (programmes and issues other than IMCI that might have affected children's health in the four districts during the study period)

through interviews with all stakeholders in the health study districts and desk review of plans, budgets and reports, and data from child-health surveys (Victora et al. 2005). Finally, we estimated the economic cost (including the value of donated goods, volunteered time by staff, and replacement of costs of assets such as building) of children's health care in IMCI and comparison districts though interview and record review at national, district, facility and household levels (Adam et al. 2003;Adam et al. 2004).

3.2.7 Kilombero Vitamin A study

A two-arm randomized double–blind trial was designed to compare the safety and efficacy of two vitamin A supplementation regimens. In the lower dose group, mothers received 60,000µg (200,000 IU) vitamin A (as vitamin A palmitate) at the time of their infant's BCG vaccination and their infants received three doses of 7,500µg (25,000 IU) at the time of vaccinations with DPT/OPV at approximately 1, 2 and 3 months of age. In the higher dose group, mothers received an additional dose of 200,000IU when their infant received the first DPT/OPV vaccination, and their infants received three doses of 15,000µg (50,000IU) alongside the three DPT/OPV vaccinations.

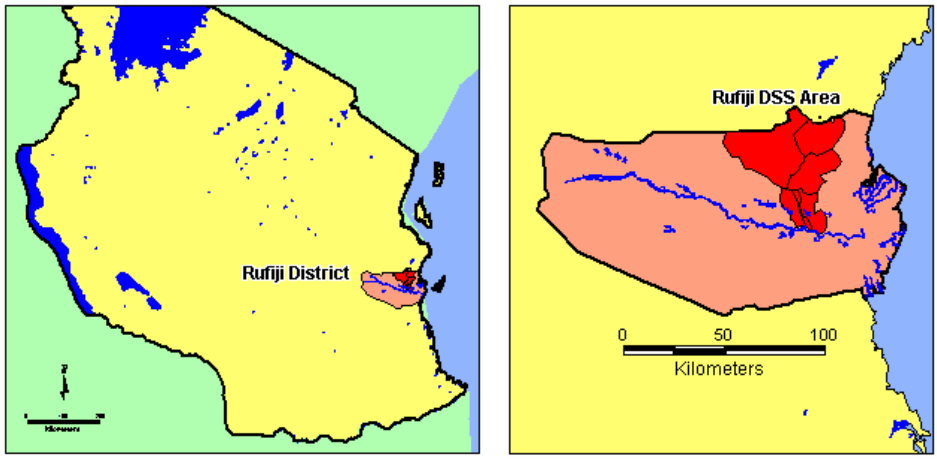
Mothers who were residents and brought their children at St. Francis Designated District Hospital Maternal and Child Health Clinic (SFDDH/MCHC) for BCG vaccination within 7 days after delivery were invited to participate in the study. Details of the study were explained to them before seeking consent. A questionnaire on demographic information was completed and a study number issued to mother-child pair for those consenting. Individual randomization to intervention or comparison groups was achieved through block randomization that was provided by the data and safety monitoring board.

Children were given a dose of vitamin A at the time of DPT/OPV vaccinations and followed up for two days for immediate adverse reactions. Safety of the two regimens was assessed through passive case detection using a Clinical Surveillance System (CSS) that was set up at the Saint Francis District

Designated Hospital (SFDDH) for previous studies (Schellenberg et al. 2001) and active visits at home for two consecutive days after each supplementation. Efficacy was assessed using biochemical indicators of vitamin A status for which blood samples were collected during cross-sectional surveys when children were aged 6 and 9 months.

3.2.8 GIS mapping

Aproximately 17,000 households in the DSA were positioned using a handheld global positioning system (GPS) (Garmin 12, Garmin Ltd Kansas, USA). Each enumerator was provided with a GPS device and recorded the coordinates of the household during update rounds. Other locations such as health facilities, markets, schools, churches and mosques were also positioned. Information on the use of health facilities for child care and pregnant women was sought from the head of household or any other reliable member of the household present during the interview. These locations were then superimposed on a base map that consisted of a series of geographical layers of the district that included; administrative ward boundaries, roads, rivers and natural reserve boundaries digitized from 1:50 000 topographical maps using MapInfo (MapInfo Corporation, New York).



Tanzania showing Rufiji District and Rufiji sentinel surveillance area.

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PART III: ARTICLES AND WORKING PAPERS

CHAPTER 4: Causes of death at the Ifakara Demographic Surveillance Area

Honorati Masanja, Rose Nathan, Sosthenes Charles, Oscar Mukasa and Salim Abdullah

This article has been submitted for the INDEPTH cause-specific mortality monograph chapter

4.1 Summary

Cause-specific mortality using verbal autopsy is one of the most reliable means of establishing causes of deaths in many developing countries where routine data system are lacking or fragmented. The study on causes of deaths was established in September 2000 in Ifakara and runs parallel to the demographic surveillance system. The DSS provides denominators for the calculation of all cause and cause-specific mortality rates.

We registered more than 1,800 deaths between September 2000 and December 2002 and obtained over 4,000 codes for causes of death from physician panel reviews. More than half (54%) of the deaths occurred at home and about one third occurred at a health facility. Most of the deaths (42%) were in children less than five years of age. Malaria is common in this area and is the number one cause of deaths across all ages. Mortality rate due to conditions arising during the perinatal period were high at 33.7 per 1000 person year. As expected, HIV/AIDS was a leading cause of death among the economically active group 15-49. Overall communicable diseases accounted for over 70% of all deaths. The public health importance of non-communicable diseases as cause of death cannot be over emphasized. Mortality rates in due cardio-vascular diseases ranged between 3 and 20 in the 50-79 and 80 years or above respectively.

The shortcomings of this study due to misclassification could not be avoided. Validation studies of the VA tools and ways to deal with misclassification errors have been well documented. Such corrective measures were not dealt with in this study and hence our results need cautious interpretation. However, despite the caveats, VA data has successfully been used to guide the priority setting and resource allocation process at district level through the use of district health services profile.

4.2 Introduction

Description of the site:

The Ifakara Demographic Surveillance System (DSS) site covers part of Kilombero and Ulanga districts which are both in Morogoro region (latitudes 8°00′–8°35′S, longitudes 35°58′–36°48′E) southern Tanzania. It is run and managed by the Ifakara Health Research and Development Center (IHRDC). Demographic surveillance in this area started as part of a social marketing programme in the two districts, that aimed at assessing coverage and the impact of insecticide treated nets on child survival (Armstrong Schellenberg et al. 1999). A baseline census was conducted between September and December 1996. A total of 25 villages are covered with a population of about 65,000 people in 14,000 households. Since January 1997 each household is visited on quarterly basis to record pregnancies, births, deaths and migration. In order to determine causes of death in the community, we started conducting verbal autopsy (VA) interviews in September 2000.

Population under surveillance

The area is predominantly rural with scattered households and the mean household size is 5.0. There are four main ethnic groups: Wapogoro, Wandamba, Wabena, and Wambunga and other smaller ones. Maize and rice are cultivated at subsistence level. The literacy rate is 88% for men and 69% for women. The rainy season is from November to May. There are occasional floods in April in several parts of the DSS area, more details are found elsewhere (INDEPTH Network 2002).

Description of health delivery system

A network of health facilities is in place. Within the DSS area, there are two government health centers, seven dispensaries and several private dispensaries. There are two district hospitals which are not located in the DSS area though one of the two is easily accessible by the DSS population. About 65% of the patients in the study site seek care from formal health facilities as first choice. Reproductive and child health services are provided for free but other services are offered within the cost-sharing framework. Apart from the

health facilities, first-line anti-malarial drugs and antipyretics are available in local shops. Traditional healers are also quite popular in this community.

Selected indicators

The top five prevalent diseases in the area during the year 2001 were malaria, ARI, pneumonia, intestinal worms and fungal infection (Council Health Management Team reports, 2001) malaria was the most common. Malaria transmission by Plasmodium falciparum is intense and perennial (Smith et al. 1993). The area also regularly experiences cholera outbreaks and sporadic cases of meningitis.

The population structure is typically young with 43% children under 15 years. In 2001 the infant mortality rate was approximately at 73.1 per 1,000 live births. The probability of dying before age five (5q0 was 131. The life expectancy at birth for men and women was 56, and 58 years respectively[1]. Although the prevalence of HIV/AIDS is not known for the DSS area, within the past four years, reports from the Kilombero district hospital which neighbours the study area show that AIDS has remained the leading cause of death among adults.

4.3 Methods

Demographic and mortality surveillance

Notification of death events originates from two sources: the quarterly round visits by the DSS interviewers and the reporting of vital events by community-based key informants or *'Vitongoji Reporters'* (VRs). DSS interviewers record on the field-based household registers: deaths, births, migrations and pregnancy events which are then entered into a computer using Household Registration System (HRS) software. Each household is visited on quarterly basis by the interviewers. The VRs method of collecting vital events runs parallel to the demographic surveillance system of quarterly reporting of vital events. There are a total 104 sub-villages, each with one reporter who is resident in the particular sub-village to facilitate easy identification of events.

[1] Life expectancy estimated from the Ifakara DSS database

The vitongoji reporter's duty is to record all deaths and births with that occur within his or her area of jurisdiction. Training of the VRs on who to record vital events on notebooks was done before they started the exercise. Once a month, each reporter is visited by a field supervisor who verifies the events and pays an allowance of 500 Tanzanian shillings (equivalent to about US$ 0.60) per event. The supervisor transfers the information from the notebooks into special forms (one for each death or birth), which are forwarded to the data room for processing. The latter system serves as a check mechanism of the former. Lists that contain identification number of the deceased, name, date of birth, sex and date of death are printed out on regular basis from the database and are provided to the VA interviewers to facilitate planning of interview schedules with the bereaved families.

Data collection

The field team comprises of 26 enumerators whose responsibility is to visit all the households every four months to update demographic events. There are three experienced DSS interviewers who were specially trained to conduct VA interviews and offer support to the community-based key informants. All the three lay-interviewers have attained secondary school education and are fluent in Swahili. There are a total of six field supervisors who have a fairly long experience in structured interviews and good leadership skills. The supervisors are responsible for providing support to the enumerators. They perform quality control by checking completeness of the questionnaires, performing repeated interviews, and spot checks on the interviewers. Two field managers who are based at the headquarters make supervisory visits regularly and oversee the running of the DSS and logistics. They are also responsible for holding weekly field meetings with the supervisors to share experiences and resolve field problems.

Implementation of the VA questionnaire

The preferred respondent is the person who took care of the deceased during the terminal illness. For children, the majority of the respondents are the mothers. Normally, the mourning period in the community lasts for about 40 days and interviews are not conducted earlier than that.

Informed consent:

VA interviews are sensitive as the respondents are usually the close relatives of the deceased. Thus, in order to gain community's acceptance in the study on causes of death using VA, the project appointed only interviewers who are residents and respected by the community members. They usually participate in various social events which include burial ceremonies. Community's willingness to take part in DSS activities such as VA interviews has further been enhanced by the provision of canvas sheets to villages by the project. Those sheets are specifically meant to provide shade during the mourning gatherings. The interviewers are trained on how to express their condolences to the bereaved family before explaining the purpose of the visit. The respondents are also reassured on the confidentiality of the information collected.

Quality control

Control measures are executed both at the field and data entry levels. Once interviews are completed, each form is checked for accuracy and completeness and spot-check done by field supervisors on a randomly selected sample of questionnaires to ascertain the accuracy of information collected and verification of the appropriateness of the respondent. Once this is done, the forms are logged in before being processed. Due to the sensitivity of the subject, repeated interviews are not conducted.

Nature of the VA tool

Three sets of VA questionnaires for specific age groups: <28 days; ≥ 28 days to 11 years and ≥ 12 years, are used in the study site. The tools originated from the WHO cause of death questionnaires and were adapted for INDEPTH cross site comparison. Each of the three questionnaires has five main parts: identification, history of events that led to death, signs and symptoms, treatment (formal and traditional) and the medical records. The open-ended part of the questionnaires includes history of illness and medical records while the rest are closed. The signs and symptoms section has filter questions that

allow for detailed information of the signs and symptoms mentioned in the open-ended part. The questionnaires were written in Kiswahili which is the national language.

Assigning cause of death

Physician reviews are used to ascertain the cause of death using *The International Classification of Diseases and related health problems*, tenth revision (ICD10) (WHO 1992). There are three physicians assigned to review VA questionnaires. Each form is reviewed and coded independently by any two of the three physicians. For each death, physicians assign an underlying and associated cause of death if any. The codes are then entered in a computer. The final diagnosis for each case is arrived at using a custom programme written in Fox pro which picks out cases where there was a consensus between the two physicians on a cause of death. Where there is disagreement, a third physician reviews the form and makes an independent diagnosis which is again compared with the previous two. If there is a consensus on at least two of the physicians, then a cause of death is established. If all the three disagreed on cause of death then the final diagnosis is coded as 'undetermined'. Up to now the established final cause of death is derived from the underlying cause only and therefore is single diagnosis.

Data management

Completed VA forms were brought to Ifakara on weekly basis where they were logged in by a filing clerk before being processed. VA data was entered by three data clerks and data processing done by a data manager. The same data clerks also processed the core DSS data. A stand-alone double data entry system built in Foxpro 2.5 with internal consistency checks was used to enter and check the data.

Data Analysis

Analysis for all results presented in this chapter was done using Visual Foxpro 9.0 and Excel 2000©. A person time matrix (time at risk) was calculated for all individuals in the DSS area excluding periods when they were outside the area under surveillance. All cause mortality rates were calculated by dividing the number of deaths in each age group by the total person time at risk in the particular age group. Cause-specific mortality rates for each age group were calculated by multiplying all-cause mortality rate by the proportion of deaths assigned to each cause. All death rates were multiplied by 1000 and ranked.

4.4 Results

2,129 deaths were registered between January 2000 and December 2002. The study on cause specific mortality using VA covered a period from September 2000 to December 2002, where a total of 1,893 deaths had a VA completed. 1,848 (97%) had a cause of death assigned and were included in the analysis. Family migration deceased relatives was the main reason for most of the missed interviews. Out of 1,848 deaths, 583 (31.5%) died in health facilities, 997 (54.0%) died at home and the remaining 268 (14.5%) occurred elsewhere. The mean recall period was five months. The distribution of deaths by age and sex is shown in Table 4.1. Most deaths occurred in the age group < 5 years (41.8%) followed by deaths in the middle age group (15 – 49 years) as illustrated in Table 4.1. An excess of males died in the age groups 50-79 and ≥80 years while female deaths were higher in the remaining age groups including those within the childbearing age (15 – 49 years).

Table 4.1 Distribution of deaths by age, sex at Ifakara DSA, 2000-2002

Age group	Male	Female	Total	M:F

	No.	%	No.	%	No.	%	ratio
Under 1 year	260	24.4	266	25.0	526	24.7	1:1.02
1 – 4 years	170	16.0	193	18.1	363	17.1	1:1.14
5 – 14 years	47	5.4	48	4.5	95	4.5	1:1.02
15 – 49 years	257	24.1	278	26.1	535	25.1	1:1.08
50 – 79 years	268	25.2	222	20.9	490	23.0	1:0.83
≥80 years	63	5.9	57	5.4	120	5.6	1:0.91
Total	**1065**	**100**	**1064**	**100**	**2129**	**100**	**1:0.99**

Table 4.2 shows annual and total age-sex specific mortality rates. Extreme age groups experienced higher mortality rates compared to other age groups throughout the study period. Overall crude death rates were similar in both males and females.

Table 4.3 shows rates per 1000 person years of top ten causes of death. Infectious diseases, conditions arising during the perinatal period and HIV/AIDS mortality rates are common, typical of rural populations in developing countries. In Table 4.4 conditions arising during the perinatal period are the leading cause of deaths in infants. Malaria and respiratory infections are among the top three killers of under-fives in this setting. Mortality due to injuries is emerging is an important cause of death in the 5-14 and 15-49 age groups.

Table 4.2 Age-sex specific mortality rates (per 1000 person years) at Ifakara DSA, 2000-2002

	Female				Male				Overall
Age group	**2000**	**2001**	**2002**	**00-02**	**2000**	**2001**	**2002**	**00-02**	**00-02**
<1	80.0	79.1	82.6	80.6	95.3	65.5	75.3	77.6	79.1
1-4	16.4	13.6	18.0	16.1	14.2	11.8	16.8	14.4	15.2
5-14	1.4	1.7	2.5	1.9	1.9	2.3	1.3	1.8	1.9
15-49	5.6	6.6	6.7	6.3	5.5	6.4	6.2	6.0	6.2
50-79	15.5	16.9	26.3	19.7	26.5	23.7	28.8	26.4	22.7
80+	86.3	101.0	149.0	113.2	151.0	104.0	127.0	126.0	119.6
CDR	**9.8**	**10.5**	**12.5**	**11.0**	**11.6**	**10.6**	**11.8**	**11.3**	**11.2**
Deaths	296	342	426	1064	337	336	392	1065	2129
Pyrs	30086	32564	34061	96711	29086	31714	33213	94013	190724

Table 4.3 Top ten causes (/1000 pyrs) of death at Ifakara DSA, 2000-2002

Rank	Cause of death (per 1000 person-years)	Rate
1	Malaria	3.32
2	Conditions arising during perinatal period	1.38
3	Respiratory infections	1.03
4	HIV/AIDS	0.70
5	Other infectious diseases	0.67
6	Other	0.63
7	Cardiovascular diseases	0.57
8	Accidents and Injuries	0.46
9	Tuberculosis	0.43
10	Diarrhoeal diseases	0.42

Table 4.4 Top ten causes of death per 1000 person-years by age group.

Rank	Cause (per 1000 person-years)					
	<1 year	**1-4 years**	**5-14 years**	**15–49 years**	**50-79 years**	**≥ 80 years**
1	Conditions arising during the perinatal period (33.7)	Malaria (9.60)	Malaria (0.87)	Malaria (1.18)	Malaria (3.65)	Malaria (28.4)
2	Malaria (23.0)	Respiratory infections (1.03)	Injuries (0.16)	HIV/AIDS (1.14)	Cardio-vascular diseases (3.45)	Cardio-vascular diseases (20.10)
3	Respiratory infections (11.2)	Injuries (0.95)	Other infectious diseases (0.10)	Other (0.55)	Other infectious diseases (2.39)	Respiratory infections (15.90)
4	Other infectious diseases (2.40)	Nutritional deficiencies (0.81)	Other (0.10)	Injuries (0.48)	Other (2.30)	Other (10.90)
5	Nutritional deficiencies (1.54)	Diarrhoeal diseases (0.72)	Tuberculosis (0.09)	Tuberculosis (0.47)	Respiratory diseases (1.87)	Other infectious diseases (9.52)
6	Diarrhoeal diseases (1.45)	Other infectious diseases (0.67)	Meningitis (0.09)	Neuro-psychiatric conditions (0.45)	Tuberculosis (1.52)	Diarrhoeal diseases (9.52)
7	Meningitis (1.31)	Other (0.38)	Neuro-psychiatric conditions (0.08)	Respiratory infections (0.33)	Malignant neoplasms (1.23)	Respiratory infections (6.17)
8	Other (1.29)	Tuberculosis (0.28)	Diarrhoeal diseases (0.07)	Cardio-vascular diseases (0.27)	HIV/AIDS (1.22)	Injuries (4.41)
9	Injuries (1.29)	HIV/AIDS (0.23)	HIV/AIDS (0.07)	Diarrhoeal diseases (0.26)	Diarrhoeal diseases (1.00)	Tuberculosis (4.05)
10	Childhood cluster diseases	Genito-urinary disease (0.19)	Injuries (0.09)	Digestive diseases (0.19)	Genito-urinary diseases (0.74)	HIV/AIDS (2.47)

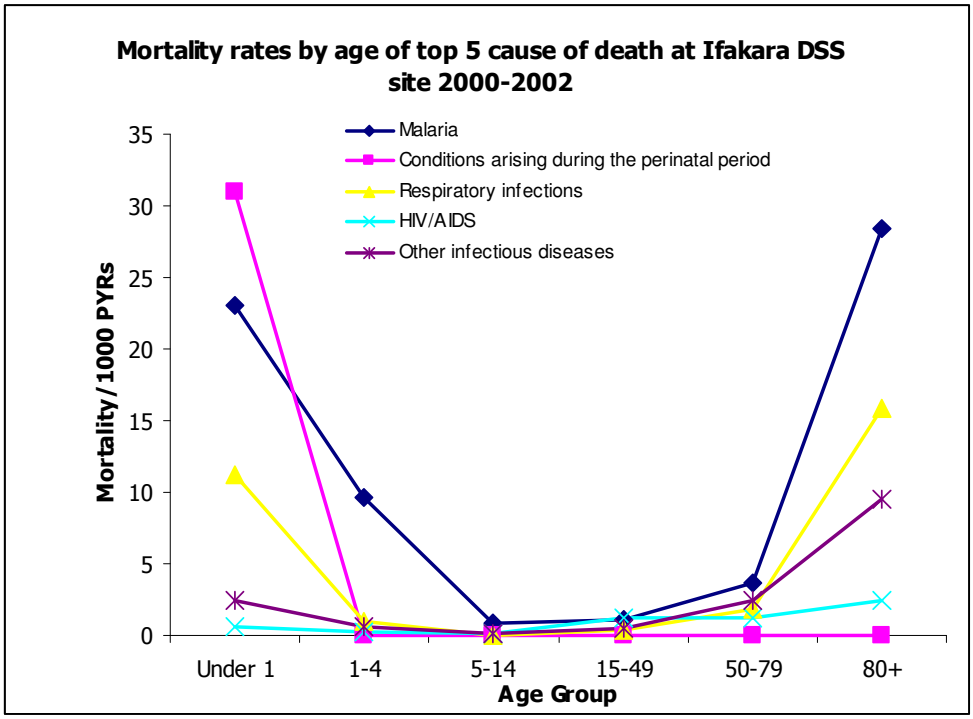

Figure 1: Mortality rates by age of top five causes of death at the Ifakara DSS site, 2000-2002

Table 4.5 Percentage of deaths by sex and by broad cause at Ifakara DSA, 2000-2002

Category	Male		Female		Overall	
	n	%	N	%	N	%
Communicable	657	70.3	681	74.6	1338	72.4
Non-communicable	160	17.1	152	16.6	312	16.9
Accidents and injuries	44	4.7	21	2.3	65	3.5
Other	11	1.2	5	0.6	16	0.9
Undetermined	63	6.7	54	5.9	117	6.3
Total	**935**	**100**	**913**	**100**	**1848**	**100**

As expected, mortality rates due to HIV/AIDS ranked highest in the 15-49 year age group. Death rates from cardio-vascular diseases ranked second after

malaria in the older age groups. Overall, malaria dominated as the major cause of deaths in this endemic rural setting.

Overall, communicable disease contributed to most deaths in this population (72.4%), and in both males and females, Table X.5. The percentage of deaths due to accidents and injuries were higher among males (4.7%) compared to females (2.3%). Approximately, 6% of the deaths were assigned as undetermined.

4.5 **Discussion**

Slightly more than 2,100 deaths were registered from January 2000 to December 2002. Verbal interviews and causes were available for 1,848 deaths (87%) from September 2000 and December 2002. Migration is common in this area, and accounted for most of the missed interviews. The study on cause specific mortality is part of the Ifakara Demographic Surveillance System that documents vital events including, births, deaths and migrations. The DSS provides accurate denominators by excluding time at risk of disease or deaths for individuals under surveillance.

In our study, the majority of deaths reported occurred at home (54%) and only about a third (32%) occurred in a health facility (data not shown). This is consistent with experiences from others rural areas in Tanzania (AMMP 1997) and is the main reason for relying on the verbal autopsy method for describing the mortality profile of a population.

An excess of adult males died in the age group 50-79 compared to females, most likely due to cardiovascular diseases. Mortality experience was similar in other age groups even for the 15- 49 category where women may have a higher risk due childbearing complications. The lack of apparent sex differentials in mortality in this age category could be attributed to many causes including HIV/AIDS, which is increasingly becoming an important cause of death in this population.

Increased drug resistance to anti malarial, poor case management and delays in seeking appropriate care are among factors contributing to high malaria death rates as shown in our results. Mortality rates due to conditions arising during the prenatal period including, prematurity, asphyxia and/or low birth weight account for the majority of deaths in this age group similar to other settings in rural Africa. HIV/AIDS ranked as the third most important cause of death and is among the top ten causes for all ages except infants. The epidemiology of HIV/AIDS has not been well described in this area hence our results may be difficult to interpret with respect to possible changes that may be occurring.

Most of the causes responsible for under five mortality including, malaria, conditions arising during the perinatal period, respiratory infections and nutritional deficiencies are either be treated or prevented (Jones et al. 2003). There was no IMCI in Kilombero and Ulanga districts during the time of this study, implementation started in 2002. The costs of IMCI strategy were shown to be similar or less than conventional care (Adam et al. 2004) and under five mortality was 13% lower than in the comparison districts (Armstrong Schellenberg et al. 2004). Vaccination coverage is high in Tanzania (Tanzania National Bureau of Statistics & Macro International Inc.Calverton 2005) and this is depicted by low rates of vaccine preventable causes, a credit to the EPI programme. The phenomenon of re-emergence of TB, which has recently been observed in many developing countries (Raviglione 2003), is clearly manifested in our site, where it features as one of the leading causes of death among adults.

Disease categories do not show sex selection except for the accidents and injuries category where more men than women die of that cause. This reflects a gender aspect of division of labour among the adults given that the specific causes in this category are associated with male economic activities of fishing (animal bites) and picking coconuts and taping palm wine (falling). However, these results should be interpreted with caution due to small numbers.

Communicable diseases account for over 70% of all deaths which compares with the rest of sub-Saharan Africa (Murray & Lopez 1994). The public health importance of non-communicable diseases as a cause of death in the study area can also not be overlooked. A closer monitoring of a possible rise in the proportion of deaths attributed to non-communicable diseases reported through verbal autopsy would be necessary in the future. Injuries and accidents in the 1-4 years age group had a substantial contribution to the causes of death. All deaths due to injuries or accidents in this age group were due to burns and drowning.

Deaths caused by meningitis are a notable feature in this setting, a total, 7 individuals died from this cause. The study area experiences sporadic outbreaks of meningitis, though at a small scale.

Limitations of results/findings

Verbal autopsy remains the most reliable tool for assigning causes of death in many parts developing world and especially in Sub-Saharan Africa where routine statistics are fragmented or non-existent. Validation of the VA tools and ways to deal with misclassification errors which are considered to have potential effect on the estimates of the cause-specific mortality based on VA studies have been debated and documented extensively (Chandramohan et al. 1994;Chandramohan, Setel, & Quigley 2001;Kahn et al. 2000;Kalter et al. 1990;Setel et al. 2006). Such corrective methods have not been dealt with here; therefore our results might suffer from that limitation. However, results from Setel and colleagues suggest that same tools that we also used here reliably estimated cause specific mortality fractions (CSMFs) for diseases of public health importance in all age groups (Setel, Whiting, Hemed, Chandramohan, Wolfson, Alberti, & Lopez 2006). The high proportion of undetermined causes among adult deaths is perhaps a manifestation of the limitation of verbal autopsies to adulthood. Due to the overlap in symptoms and signs between malaria and other acute febrile illnesses such as pneumonia, coders assumed most of these deaths were due to malaria unless there was strong evidence to suggest otherwise.

TB and other opportunistic infections that are closely associated with HIV/AIDS limit the power of the VA as a tool to assign causes of death to such cases. Many deaths that might have primarily been due to TB could be easily classified as HIV/AIDS.

Information generated from VA is invaluable to both district health planners and researchers because of its utility in making efficient allocation of scarce resources and planning for appropriate community health interventions. This has indeed been successfully demonstrated in some Tanzanian rural districts, Rufiji and Morogoro (de Savigny et al. 1999). The experience showed a dramatic improvement in allocation of health resource as guided by the District Health services profile developed from the VA diagnoses (Tanzania Essential Health Interventions Project & Ministry of Health 2002). Verbal autopsies also provide useful baseline information for monitoring and evaluation of health service delivery and interventions to specific diseases.

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CHAPTER 5: Spatial analysis of access to health care for under fives and pregnant women in Rufiji District Tanzania

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5.1 Introduction

Health service provision through primary health care is undoubtedly the most reliable means of reaching the majority of the populations in the developing world. However, health systems in Africa face the challenge of increasingly diverse and complex health problems, rapid population growth and inadequate resources to respond to these demands. Further, optimal access to primary health care services is impeded by many factors including physical, temporal, organizational, social, cultural, gender and economic factors. Geographic factors play a major role in modulating access to and utilization of health services. People living far from health services tend to have lower rates or utilization and consequently poorer health outcomes (Perry & Gesler 2000). Proximity to health services has been associated with decreased maternal and child mortality (Debpuur et al. 2002;van den Broek et al. 2003) and increased compliance with new intervention programmes (de Souza et al. 2006)

The health sector in general and Africa in particular have been late in adopting Geographic Information Systems (GIS) as a tool for managing and understanding health data, either in research or in health services (de Savigny & Wijeyaratne 1995). However recent years have seen several advances. An digital atlas of malaria risk in Africa has been produced based on prediction models using spatial databases of infection prevalence, biologic transmission intensity and climate (MARA Collaboration 1998). This, when combined with population data allowed estimation of populations at risk of exposure, morbidity and mortality (Snow et al. 1999). Practical GIS applications have been produced and increasingly used. A good example is the WHO HealthMapper software application, originally used by large disease control programs such as Guinea Worm Eradiation and the Onchocerciasis Control Program in Africa, and now used by many students, health researchers and health information systems. But it is fair to say that in Africa in general, there has been limited use of the GIS technology in health systems and health systems research that has, as a result, hindered its contribution as a health planning and management tool.

That is changing. There are encouraging prospects on the use of GIS in health systems research in recent work associated with demographic surveillance systems (Tanser, Gijsbertsen, & Herbst 2006) and that ongoing. GIS has been applied to equitably distribute workload among fieldworkers in a large survey in South Africa (Tanser 2002). A study in Kenya reported the use of GIS to model access and utilization of health services as tool to monitor millennium development goals to reduce the burden of HIV/AIDS, tuberculosis and malaria (Noor et al. 2006). Models to investigate rural and peri-urban usage of health facilities and the quantification of the effect of physical access to usage have been studied in rural South Africa (Tanser, Gijsbertsen, & Herbst 2006) . The models have been extended and applied to a rural area in Tanzania and are the subject of this paper.

Most parts of rural Tanzania have a good network of primary health care facilities as a result of post independence policies that aimed at equitable health services for all. Although geographical variations in access to health services exist, on average, rural populations in Tanzania tend to be nearer to health facilities compared to neighbouring countries (Beegle 1995). Approximately 90% of the population is within 1 hour walking distance to a government health facility (Tanzania National Bureau of Statistics 2003) where care for under-fives and pregnant women are officially free in government health facilities.

Despite this good network of health facilities in most parts of the country, studies on spatial barriers of access to health services and travel time in Tanzania are lacking. This could partly be due to the assumption that the majority of the population are within 5 km from a health facility, lack of interest or expertise in modelling such patterns.

To investigate spatial patterns of access and travel to health facilities in a rural setting in Tanzania, we used information from geographically positioned households and health facilities normally used by the households for under

fives and pregnant women care to assess the pattern of primary health care usage in the Rufiji District Surveillance area.

5.2 Methods

Study area

The study area has been described in detail elsewhere; briefly the Rufiji Demographic Surveillance Area (DSA) extends between latitudes 7.47° and 8.03° South and longitudes 38.62° and 39.17° East. The Rufiji DSS is in Rufiji District, Tanzania, about 178 km south of Dar es Salaam. Rufiji is one of six districts of the Coast Region, the others being Bagamoyo, Kibaha, Kisarawe, Mafia, and Mkuranga. Rufiji, in the south, has 6 divisions, with 19 wards, divided into 94 registered villages and 385 hamlets. The district covers an area of about 14,500 km^2. The Rufiji DSS operates in 6 contiguous wards and 31 villages (about 60 km long × 30 km wide) and covers an area of 1813 km^2.

Rufiji has a population of about 182,000, of which 85,000 (about 47% of the district) is under surveillance in the DSA. The mean household size for the whole district is about 5.0 (TBS 1994). The district is largely rural, but the population is clustered around Utete (district headquarters), Ikwiriri, Kibiti, and Bungu townships. The main economic activities are subsistence farming and fishing.

The DSAs main transportation route is the north–south Dar es Salaam–Lindi and Mtwara trunk road, half of which is paved; and the other, unsealed. Unpaved feeder roads and tracks link most of the villages to this trunk road.

The geography is characterized by river flood plains and gentle uplands with maximum elevation of 500m above sea level. The vegetation mainly composed of tropical forest and grassland. The district receives an average annual precipitation of 800-1000.mm. There are two rainy seasons; with short rains in October to December and long rains in March to May. Occasional floods in parts of the DSA deposit rich alluvial soils on an area stretching more than five kilometres on both sides on the Rufiji River. The district borders the

Selous Game Reserve which has a variety of wild animals. The reserves acts as natural barrier between the Rufiji District and Morogoro Rural district (INDEPTH Network 2002)

Primary Health Care in Rufiji District

Like most districts of Tanzania, Rufiji District has good network of health facilities that are located within villages. In total there are 55 health facilities: 2 hospitals (1 government and 1 mission), 5 government health centres, 44 government dispensaries, and 4 non government dispensaries. A private dispensary based at Kibiti offers the services of a mobile clinic in some parts of the district. The DSA is served by one of the two hospitals, two of the five health centres and 11 of the 44 dispensaries. Over-the-counter drugs are available from many private shops and kiosks in the villages. Many people also obtain services from traditional healers, including traditional birth attendants (de Savigny et al. 2004). Malaria and waterborne diseases, such as cholera and diarrhoea, are the major health problems in the area, according to both the health services and local people. TB and HIV/AIDS are also major shares of the burden of disease according to data from the DSS.

GIS for primary health care research

In 2002 approximately 14,000 households in the DSS area were geo-positioned using a hand held global positioning systems (GPS) (Garmin-12, Garmin Ltd., Kansas USA). Each enumerator was provided with a GPS device and recorded the coordinates of each household during one of the quarterly visits to the household. Key locations in each village, including health facilities, markets, churches, mosques and schools were also positioned. In a subsequent visit we sought to determine the usual choice of health service unit by the household. We asked a question to the head or a knowledgeable member of the household present during the interview “which health facility they normally used for general, under-five and maternal care.” We were able to visit approximately 12,000 household because the implementation of the questionnaire had started a few weeks after the start of the update round. Results for this question were available for approximately 9,392. In approximately 1,330 of the households respondents were not asked this

question because they were either away at the time of the survey or there was no one to provide reliable information on the health facility usage by the household.

The households and health facility point locations were then superimposed on a base map of the DSS area comprising of a series of geographical layers of the area including roads, rivers and natural reserves digitized from 1:50 000 topographical maps using MapInfo 7.0 (MapInfo Corporation, Troy, NY,USA)

Prediction model of health facility catchments

We built our walking and travel (using public or private transport) time models to nearest health facilities using the *costgrow* algorithm in raster GIS using IDRISI (Clark University, Worcester, MA, USA). For the transport model we initially superimposed the road network on a 10 meter pixel raster grid with friction values corresponding to speeds shown in Table 1. The same algorithm was also used to predict household catchment areas of nearest health facilities for both walking and travel models. Walking and travel speeds on each surface were assigned based on local knowledge and national speed limits on major roads. For the walking model, a speed or friction value of 5 km/h was assigned to all major and secondary roads and 4 km/h on minor roads or footpaths. Friction values between roads, tracks or footpaths were assumed to be the same as the slowest footpath value.

The *costgrow* algorithm uses the friction values to compute a path of least resistance from each pixel on the image to nearest target cell, in this case health facilities.

Indices of health facility usage

Cross tabulations of model predicted health facility use against actual reported use were used to produce an error matrix. We then calculated the inclusion and exclusion errors as defined by Tanser and colleagues (Tanser et al. 2001). Inclusion error was defined as the proportion of households using a particular health facility which are from other catchment areas and the exclusion error was defined as the proportion of households from a particular

catchment area which use another facility or none at all. A clinic with a high inclusion error attracts patients from within other catchment areas while health facilities with high proportion of households within their catchment area which use other health facilities will have high exclusion errors

The differences between the expected and the actual usage were used to compute the distance usage index (DUI) of each facility (Tanser, Hosegood, Benzler, & Solarsh 2001). The DUI is derived as the sum of travel times between all households within a predicted health facility catchments and the health facility divided by the sum of travel times between all households who reported using a particular health facility and the health facility itself. It measures how strong patients are attracted to or repelled from a health facility. Thus a high DUI greater the 100% indicates greater attraction of a particular health facility to patients outside its catchment area, while a low DUI less that 100% implies that the facility only attracts patients from within its catchment area and mostly from short distances.

5.3 Results

A total of 9,392 (67%) of the 14,000 geo-referenced households in 2002 had complete data on access to health facility. Average travel times to health facilities for pregnant women and for children younger than five years were 36.8 and 36.5 minutes respectively. (78 %) of the DSA population is within 30 minutes from a health facility.

Table 1: Speed assignment in the transport model

Description	Public transport model (km/h)	Walking model (km/h)
Level 1 road	100	5
Level 2 road (primary)	50	5
Level 3 road (secondary	30	5
Level 4 road	20	5
Level 5 road (tracks)	5	4

Table 2 shows the error matrix and other spatial indices of the actual against predicted travel time and health facility usage. Three government

dispensaries, Kimbuga, Mng'aru and Mlanzi had low inclusion errors 2.2%, 1.5% and 0.4% suggesting repulsion from these health facilities. A large proportion of households whose catchment area is Mariam Consolata used other health facilities or none (exclusion error=92%)..

The distance usage indices for both children younger than five and pregnant women were similar, 96.3% and 96.0%. All three private dispensaries in the DSS area except the hospital had DUI values less than 50% suggesting repulsion.

The predicted health facility catchments from two models (either using some form of transport or walking), were similar with differences only in the Kibiti area where the predicted catchment area for Mariam Consolata Mission dispensary is much smaller for the walking model compared to the transport model.

95% of children younger than five in the least poor quintile had access to health facilities of less than half an hour compared to 71% in the poorest quintile. The average travel time to a health facility for children in the least poor quintile was 17 minutes compared to 42 minutes in the poorest quintile.

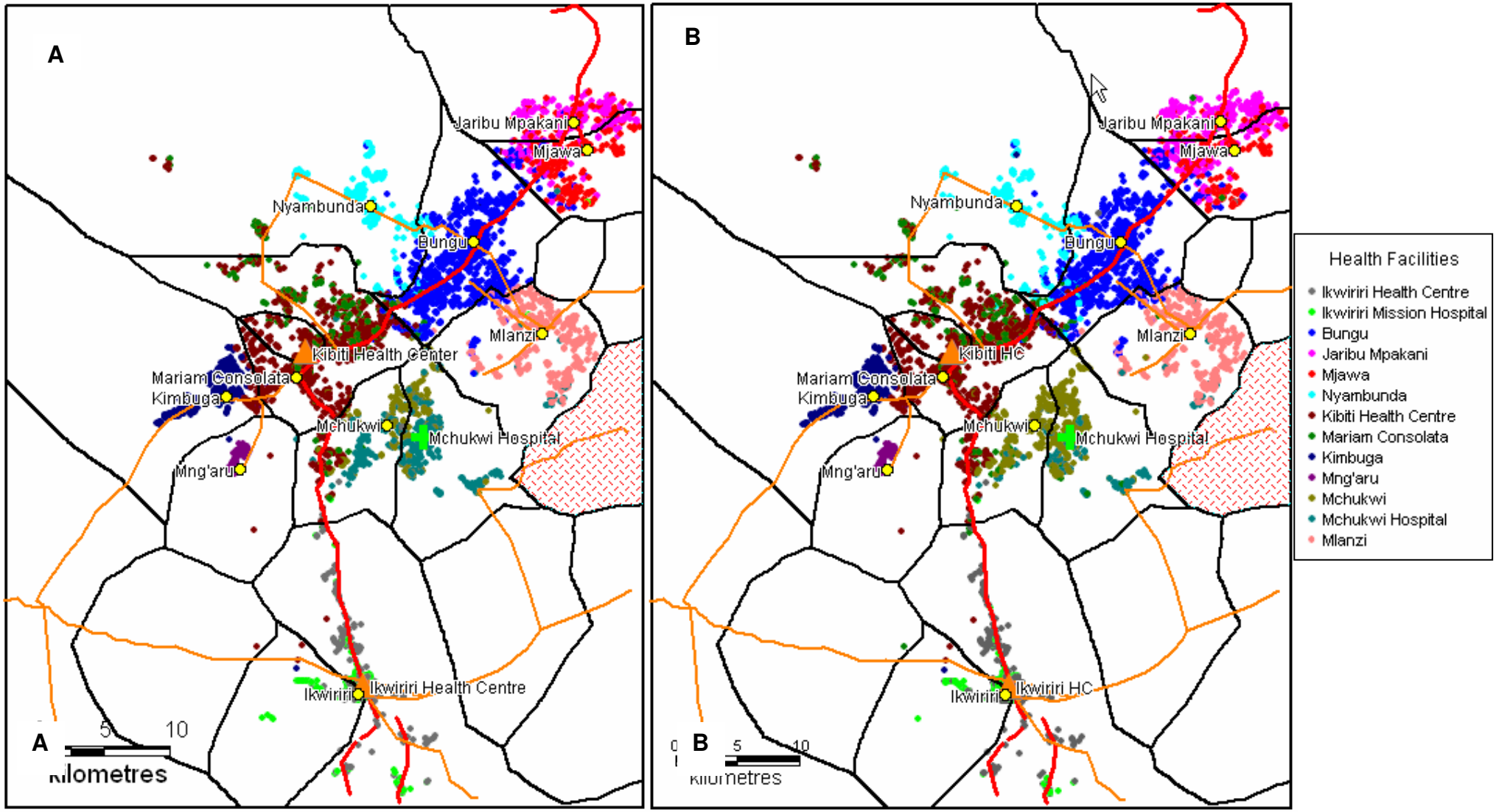
Table 2: Error matrix of the relationship between actual health facility usage and nearest facility. Inclusion and exclusion error, average travel time and distance usage index by health facility for under five children.

	Actual clinical usage																	
Name of nearest health facility	Ikwiriri HC	Ikwiriri Mission	Bungu	Jaribu Mpakani	Mjawa	Nyambunda	Kibiti HC	Mariam Consolata	Kimbuga	Mng'aru	Mchukwi	Mchukwi Hospital	Mlanzi	Total	Unknown	Exclusion error (%)	Mean time (minutes)	DUI (%)
Ikwiriri HC	491	81	0	0	0	0	3	12	1	0	0	1	0	589	418	16.6	17.6	80.7
Ikwiriri	20	54	0	0	0	0	1	1	1	0	0	0	0	266	228	79.7	18.5	45.8
Bungu	1	0	894	1	2	54	8	24	0	0	0	2	2	988	756	9.5	43.9	80.4
Jaribu Mpakani	0	0	43	407	102	1	1	2	0	0	0	5	0	561	403	27.5	33.1	76.9
Mjawa	1	0	16	71	163	0	0	1	0	0	0	0	0	252	174	35.3	34.1	58.9
Nyambunda	0	0	3	0	0	138	27	34	1	0	0	0	0	203	130	32.0	50.9	59.3
Kibiti HC	0	0	18	0	0	1	464	198	1	0	1	1	0	684	444	32.2	41.5	55.5
Mariamu Consolata	1	1	0	0	0	0	487	43	2	0	6	3	0	543	429	92.1	51.3	7.2
Kimbuga	0	0	0	0	0	0	44	1	316	1	0	0	0	362	198	12.7	35.3	97.5
Mng'aru	0	0	0	0	0	0	2	0	1	65	0	0	0	68	32	4.4	19.4	95.7
Mchukwi	1	0	0	0	0	0	26	14	0	0	212	28	0	281	147	24.6	34.8	47.7
Mchukwi Hospital	0	0	0	0	0	0	0	9	0	0	236	132	0	377	168	65.0	38.7	61.1
Mlanzi	0	1	40	0	0	0	0	3	0	0	1	9	532	586	215	9.2	38.9	96.3
Total	704	137	1,014	479	267	194	1,063	342	323	66	456	181	534	9,353	3,742	58.2		
Inclusion error (%)	30.3	60.6	11.8	15.0	39.0	28.9	56.3	90.0	2.2	1.5	53.4	72.9	0.4					

Table 3: Error matrix of the relationship between actual health facility usage and nearest facility. Inclusion and exclusion error, average travel time and distance usage index by health facility for pregnant women

	Actual clinic usage																	
Name of nearest health facility	Ikwiriri HC	Ikwiriri Mission	Bungu	Jaribu Mpakani	Mjawa	Nyambunda	Kibiti HC	Mariam Consolata	Kimbuga	Mng'aru	Mchukwi	Mchukwi Hospital	Mlanzi	Total	Unknown	Exclusion error (%)	Mean time (minutes)	DUI (%)
Ikwiriri HC	424	187	0	1	1	0	4	2	2	0	0	7	0	628	378	67.5	19.3	82.5
Ikwiriri	162	140	0	0	0	0	2	0	1	0	0	1	0	306	188	54.2	14.9	43.4
Bungu	1	0	995	1	2	35	8	16	2	0	1	1	2	1,064	679	7.5	44.1	83.1
Jaribu Mpakani	1	0	42	276	211	1	2	0	1	0	0	1	0	535	425	48.4	35.3	77.3
Mjawa	0	1	12	43	194	1	0	0	0	0	0	1	0	252	174	23.0	32.9	50.8
Nyambunda	0	0	4	0	0	179	29	30	0	0	0	0	0	242	91	26.0	46.2	76.2
Kibiti HC	0	0	15	0	0	0	487	205	1	0	1	3	0	712	415	31.6	39.8	54.2
Mariamu Consolata	1	1	0	0	0	0	563	30	3	0	8	7	0	613	358	95.2	55.4	6.5
Kimbuga	0	0	0	0	0	0	46	0	319	0	0	0	0	365	195	12.6	35.3	96.5
Mng'aru	0	0	0	0	0	0	2	0	1	65	0	0	0	68	32	4.4	19.2	100
Mchukwi	2	0	0	0	0	0	28	5	0	0	112	128	0	275	150	59.3	38.5	45.1
Mchukwi Hospital	0	0	0	0	0	0	0	0	0	0	109	234	0	343	177	31.8	35.5	51.8
Mlanzi	1	1	42	0	0	0	0	0	0	0	0	20	426	490	204	13.1	38.8	96.0
Total	592	330	1,110	321	408	216	1,171	288	330	65	231	403	428	5,893	3,466	34.1		
Inclusion error (%)	28.4	57.6	10.4	14.0	52.5	17.1	58.4	89.6	3.3	0.0	51.5	41.9	0.5					

Figure 1: Walking model: Reported use versus predicted access to health care in Rufiji DSS (A) pregnant women, (B) under fives



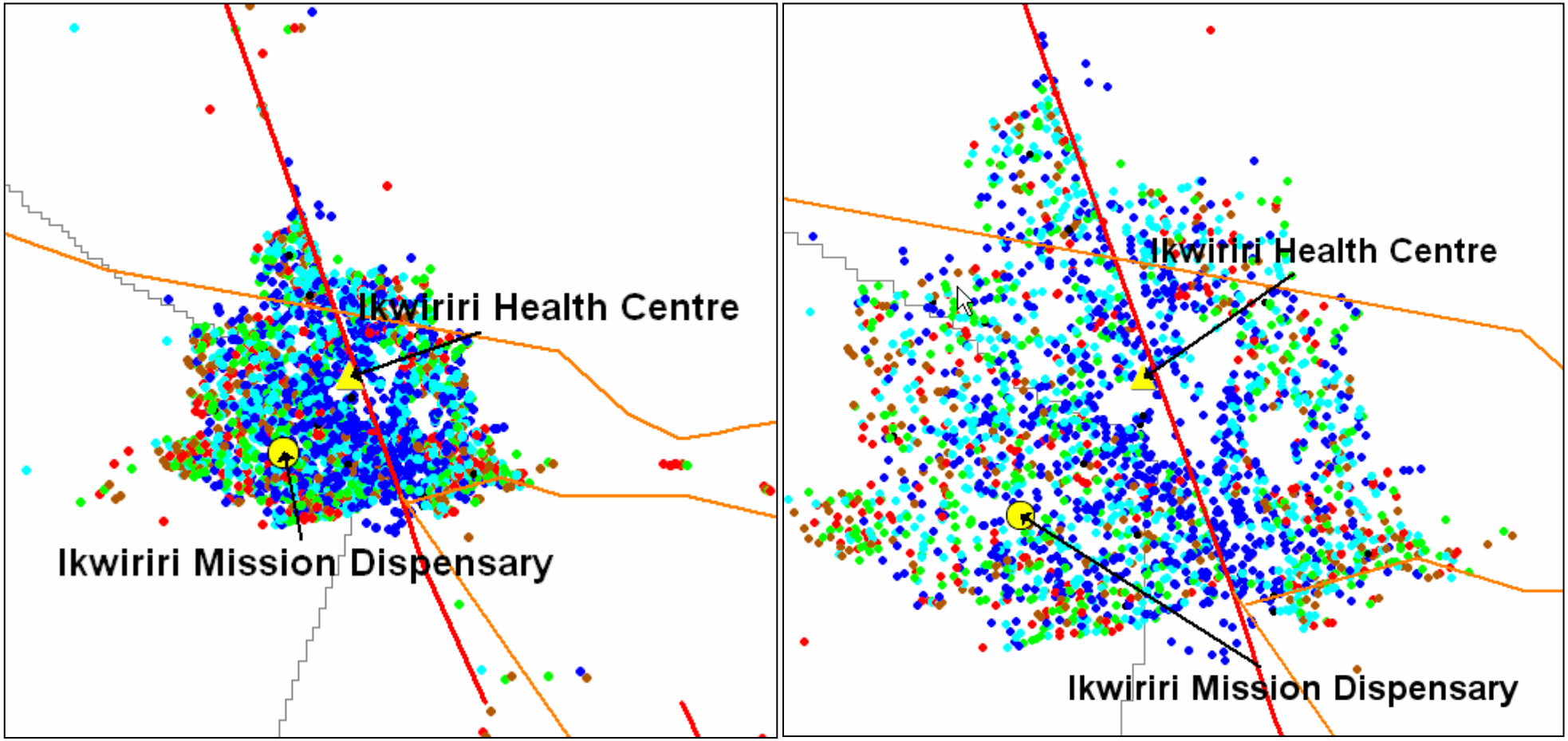
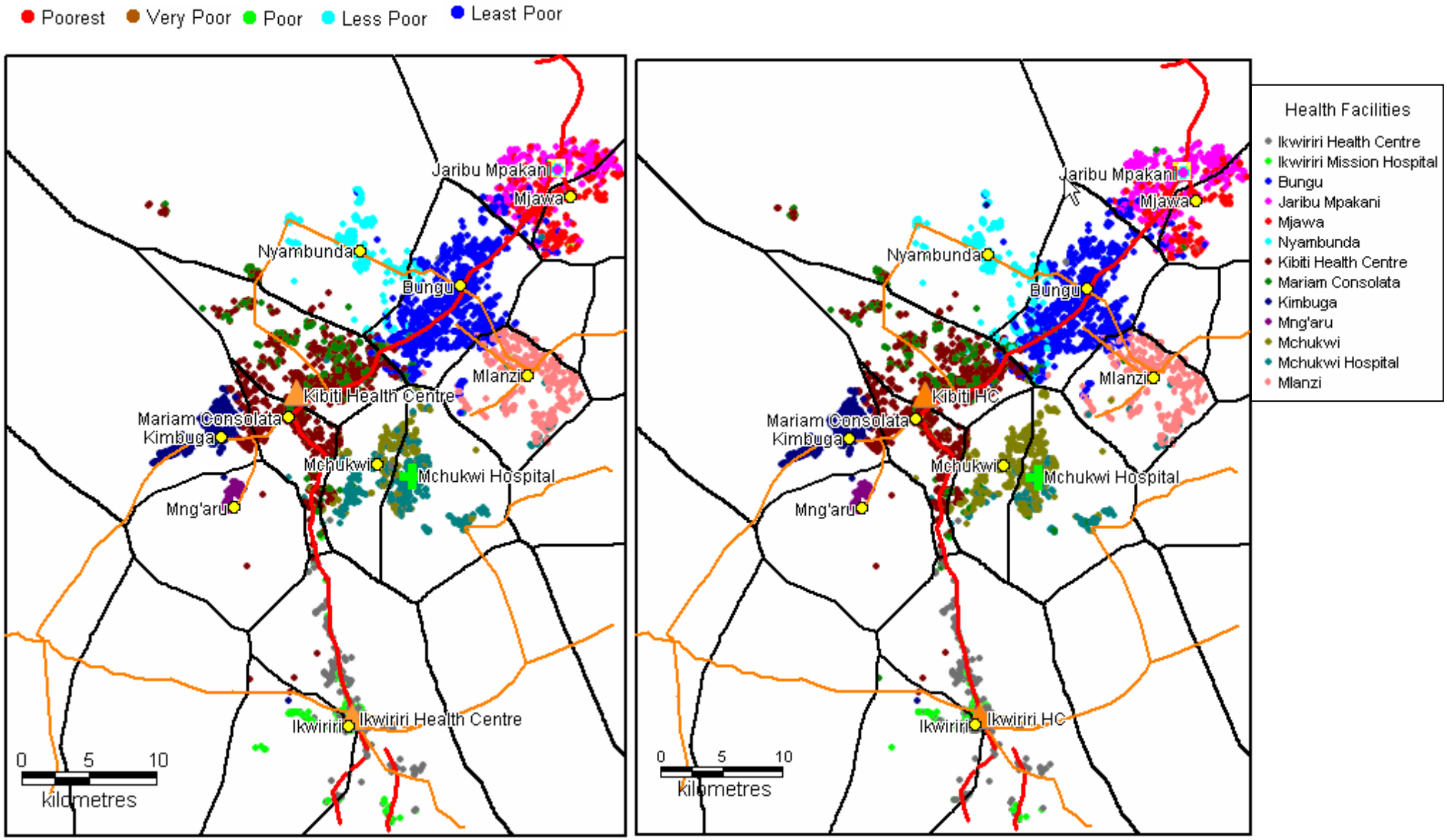


Figure 2: Socioeconomic status quintiles in Ikwiriri, Rufiji


Poorest
Very Poor
Poor
Less Poor
Least Poor
Jaribu Mpakani
Mjawa
Nyambunda
Bungu
Mlanzi
Kibiti Health Centre
Mariam Consolata
Kimbuga
Mchukwi
Mchukwi Hospital
Mng'aru
Ikwiriri
Ikwiriri Health Centre
0
5
10
kilometres
Kibiti HC
Ikwiriri HC
Health Facilities
Ikwiriri Health Centre
Ikwiriri Mission Hospital
Bungu
Jaribu Mpakani
Mjawa
Nyambunda
Kibiti Health Centre
Mariam Consolata
Kimbuga
Mng'aru
Mchukwi
Mchukwi Hospital
Mlanzi

Discussion

Using GIS software we were able to analyze spatial access to health care in pregnant women and children younger than five in Rufiji sentinel surveillance area. The mean travel time to health facilities in Rufiji DSA is less than one hour. However, important inequities may be masked by the averages. Our data also shows that the poorest people have on average much longer travel times compared with the least poor who live closer to health facilities.

Although there is cost sharing of health services through different schemes, health care in government health facilities is still officially free for pregnant women and children younger than five years in Tanzania. This is meant to increase utilization of health services for the poor mothers and children who cannot afford them. Our study did not assess utilization rates, but findings from a large health impact in the district around the same time as our study showed relatively high utilization rates among children compared to other developing countries (Armstrong Schellenberg et al. 2003). The low distance usage indices in particular in the three private health facilities in the DSS area is probably a reflection of the costs that people including pregnant women and children have to pay when they access them.

Proximity to health facilities favoured children from least poor families than from poorer households. Their mean travel time was one third of what a child from the poorest quintiles would need to travel to access a facility. Our results are in agreement with what has been reported in another study by Armstrong and colleagues (Armstrong Schellenberg, Victora, Mushi, de Savigny, Schellenberg, Mshinda, & Bryce 2003). In their study, they found that children from least poor households were more likely to receive better quality health care than children from poorer families and were more likely to have had shorter distance to health facilities.

Our study is bound to some limitations regarding the assumptions on the travel speeds and land use. For the model, we made educated guesses on the speeds for the different road levels in the district. Measured average speeds on the

different road levels may improve the model estimates. Similarly, information on natural barriers to movement would have enhanced the validity of our model.

There are several implications of this initial GIS study that are being followed up. First the travel time model is being refined to take account of measured speeds, and land use barriers. Secondly, the travel time DUI is being explored to determine if it correlates with other indicators of health facility quality. Third, we will examine the travel time model to determine if there is any population cluster that would benefit from either a new static health facility, or from dedicated outreach services. Fourth, we will examine how the DUI operates regarding compliance with chronic care interventions such as TB DOTS or anti-retroviral therapy which require repeated return visits to health facilities. Finally, we will take advantage of the health service and population spatial databases to examine other environmentally determined health risks and their interventions. A good example of this is malaria transmission in relation to coverage density of insecticide treated nets which tend to have higher coverage among the least poor.

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CHAPTER 6: A randomized control trial of the safety and efficacy of two vitamin A supplementation schedules in Tanzanian infants

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6.1 Abstract

Objectives: To evaluate the safety and efficacy of vitamin A supplementation alongside routine vaccination in young infants.

Design: A two-arm randomised double-blind controlled clinical trial.

Setting: District hospital and Mother and Child Health Clinic, Ifakara, southern Tanzania.

Participants: Newborn infants, followed until 9 months of age, and their mothers.

Interventions: Lower dose group – 60,000µg (200,000IU) vitamin A (as vitamin A palmitate) for mothers shortly after delivery and 7,500µg (25,000IU) to their infants alongside vaccinations at approximately 1, 2 and 3 months of age. Higher dose group – a second maternal dose of 200,000IU when their infant was aged 1 month, and 15,000µg (50,000 IU) to the infant alongside routine vaccinations at 1, 2 and 3 months of age.

Main outcome measures: Safety – community-based active and hospital-based passive case detection. Efficacy – prevalence of vitamin A deficiency (VAD) defined as a Modified Relative Dose Response (MRDR) test result ≥0.060 at 6 months of age.

Results: Higher dose vitamin A supplementation was well tolerated by mothers and infants. The prevalence of VAD in 6 month old infants was 43% (125/293) in the higher dose arm and 47% (132/282) in the lower dose arm (relative risk 0.91 (95% confidence interval 0.76-1.09), p=0.32). Serum retinol concentrations and the incidence of illness episodes were also similar in the two groups. Some vitamin A capsules degraded towards the end of the study, but the results were essentially unchanged when infants who could have received such doses were excluded.

Conclusions: This study provides evidence that doubling the doses of vitamin A to mothers and their young infants is likely to be safe but is unlikely to reduce short-term morbidity or to enhance the infant's biochemical vitamin A status at 6 months of age. The stability of vitamin A capsules, especially those with 25,000 IU and 50,000 IU, merits further investigation.

6.2 Introduction

There is strong evidence that supplementation with vitamin A from the age of 6 months reduces morbidity and mortality in areas with endemic vitamin A deficiency (VAD) (Beaton et al. 1993;Fawzi et al. 1993). In practice, one of the main opportunities for supplementing this age group is at the time of measles vaccination, usually given as soon as possible after the infant is 9 months old. However, because a high proportion of all child deaths occur before the age of 9 months the effects of earlier vitamin A supplementation have been investigated. Results have been conflicting (Daulaire et al. 1992;Humphrey et al. 1996;Malaba et al. 2005;Rahmathullah et al. 2003;West, Jr. et al. 1995). Two trials in Asia gave approximately 50,000IU of vitamin A to infants within the first few days of life, and showed 22-64% reductions in infant mortality (Humphrey, Agoestina, Wu, Usman, Nurachim, Subardja, Hidayat, Tielsch, West, Jr., & Sommer 1996;Rahmathullah, Tielsch, Thulasiraj, Katz, Coles, Devi, John, Prakash, Sadan and, Edwin, & Kamaraj 2003). A more recent trial involving 9,208 mother infant pairs in a less vitamin A deficient population in Zimbabwe showed that 400,000IU of vitamin A for mothers and 50,000IU for their infants, given within 96 hours of birth, did not lower infant mortality (hazard ratio 1.28 (95% confidence interval 0.83, 1.98)) (Malaba, Iliff, Nathoo, Marinda, Moulton, Zijenah, Zvandasara, Ward, & Humphrey 2005).

A further study explored the effect of supplementation in slightly older infants and made use of the Expanded Program on Immunisation (EPI). EPI routinely delivers three doses of diphtheria-pertussis-tetanus/oral polio vaccines (DPT/OPV) (sometimes with Hepatitis B and/or Haemophilus influenzae vaccine) to millions of children younger than 6 months living in VAD endemic settings. The World Health Organization (WHO) co-ordinated a randomised, double-blind, placebo-controlled trial in 9,424 infants to investigate the effects of supplementation with 25,000IU of vitamin A at the time of these routine vaccinations at 6, 10 and 14 weeks of age. This study, conducted in Ghana, India and Peru, showed that the intervention was safe but produced only a modest and short-lived improvement in vitamin A status when children were aged 6 months (serum retinol ≤0.70µmol/L 29.9% versus 37.1%, risk difference -7.2% (95%

confidence interval -14.3, -0.2%). The benefits were no longer apparent on biochemical testing when the infants were 9 months old (WHO/CHD Immunisation-Linked Vitamin A Supplementation Study Group 1998).

Supplementation of mothers has been shown to improve the vitamin A intake of breast-feeding infants. Four studies, all in Asia (Basu, Sengupta, & Paladhi 2003;Humphrey & Rice 2000;Rice et al. 1999;Roy et al. 1997;Stoltzfus et al. 1993), showed that a single dose of 200,000IU-300,000IU of vitamin A given to mothers within three weeks of birth significantly increased their breast milk retinol concentration for between three and eight months. Combined supplementation of mothers, shortly after delivery, and their young children may help improve children's vitamin A status. An assessment of vitamin A requirements in infancy suggested that supplementation of women post-partum with two doses of 200,000 IU, and infants with three doses of 50,000 IU in the first 6 months of life would be sufficient to prevent VAD in the majority of infants (Humphrey & Rice 2000) Metabolic studies also suggested that this dosing regimen was very unlikely to be toxic (Allen & Haskell 2001).

We conducted a double-blind, randomised two-arm study to compare the safety and efficacy of the previously-tested lower dose regimen (25,000 IU units at the time of DTP/OPV doses 1, 2 and 3) with that of the suggested higher dose regimen (a further 200,000 IU dose to mothers when their infants were 1 month old and 50,000 IU units for infants at the time of DTP/OPV doses 1, 2 and 3).

6.3 Methods

Setting

The study was conducted in Ifakara, southern Tanzania, where 56% of children aged 6 months to 6 years had serum retinol concentrations ≤0.70μmol/L in 1997 (TFNC & Ministry of Health 1998) The town is served by St Francis Designated District Hospital (SFDDH) and an adjacent Maternal and Child Health Clinic (MCHC). The MCHC provides routine EPI vaccinations: Bacille-Calmette-Guerin (BCG) and OPV are given immediately after birth, doses of DPT/OPV at 1, 2 and 3 months, and measles vaccination at 9 months of age. The study area covers a

6 km radius from SFDDH ensuring good access to the hospital-based clinical surveillance systems. The study was approved by the local and national ethics review committees in Tanzania and those of the London School of Hygiene and Tropical Medicine and the World Health Organisation.

Design and intervention

This two-arm randomised double–blind trial was designed to compare the safety and efficacy of two vitamin A supplementation regimens. In the lower dose group, mothers received 60,000µg (200,000 IU) vitamin A (as vitamin A palmitate) at the time of their infant's BCG vaccination and their infants received three doses of 7,500µg (25,000 IU) at the time of vaccinations with DPT/OPV. In the higher dose group, mothers received an additional dose of 60,000µg (200,000 IU) when their infant received the first DPT/OPV vaccination, and their infants received three doses of 15,000µg (50,000 IU) alongside the three DPT/OPV vaccinations. In accordance with national guidelines, all infants received 30,000µg (100,000 IU) vitamin A at the time of measles vaccination. Vitamin A capsules providing different doses were manufactured by Accucaps Industries, Canada (25,000 IU and 50,000 IU) and Aprilia, Italy (200,000 IU), and were supplied to the project by the World Health Organisation. Capsules were transported and stored in light-proof boxes and kept in an air-conditioned room at the trial site.

Recruitment, randomisation and administration of vitamin A

Mothers who were resident in the study area and brought their infants to SFDDH/MCHC for BCG vaccination within 7 days of birth were invited to participate in the trial. Details of the trial were explained and a series of standardised questions asked to ensure adequate understanding before seeking written, informed consent. Demographic information was documented before the lowest available study number was assigned to mother-infant pairs. Individual randomisation was achieved using a list of study numbers which had been randomly assigned to an intervention arm in blocks of 10, generated by the data and safety monitoring board.

Mothers were invited to bring their child to the MCHC for vaccination and vitamin A dosing on a specific date when the child would be approximately one month old. Before each supplementation, project clinical officers examined mothers and/or their infants and a standardised morbidity questionnaire was completed. The contents of a vitamin A capsule, labelled only with the participant's study number, were squeezed into the recipient's mouth. Mother-infant pairs who had not attended the MCHC within one week of their appointment were visited at home to confirm residence and survival status, and, if present, reminded to attend the study clinic.

Follow-up

The timing of the interventions and follow-up is summarised in figure 1. Safety was assessed throughout the study by passive case detection using a Clinical Surveillance System (CSS), and actively at home on each of the two days following each supplementation. The primary assessment of efficacy was based on biochemical indicators of vitamin A status for which blood samples were collected during cross-sectional surveys when children were aged 6 and 9 months.

Assessment of safety

Mothers were encouraged to bring their infant to the CSS if they experienced any illness at any time during follow-up. The CSS was established at SFDDH in 1994 to document all outpatient attendances of study infants and paediatric admissions, around the clock, every day of the year. Specially trained Clinical Officers examined and completed a standardised pre-coded morbidity questionnaire for each infant including, for example, the presence or absence of fever, bulging fontanelle, diarrhoea, clinical malaria and anaemia. The CSS thus generated detailed clinical data for the assessment of safety and secondary efficacy endpoints. Necessary laboratory tests and appropriate management were provided free of charge.

Active clinical surveillance was by field workers visiting mothers and/or their infants at home for two consecutive days after each maternal and infant

supplementation. A standard form was completed documenting any symptoms or clinical signs of illness. Study participants found to have potentially serious clinical symptoms or signs were asked to attend the hospital for re-examination by a study clinician.

Assessment of efficacy

Vitamin A status was assessed by analysis of capillary blood samples collected from infants during cross-sectional surveys at age 6 and 9 months. A field worker invited mother-infant pairs to attend these surveys, having documented that the infant was alive and still resident in the study area. Those who did not attend were re-invited each week for a total of four weeks. Breast milk was collected into 50ml falcon screw-top tubes for subsequent analysis of retinol content. A single oral dose of 3, 4-didehydroretinyl acetate (DRA) was administered to mothers (8.8µmol) and/or infants (5.3µmol) for assessing the modified-Relative-Dose-Response (MRDR test) as previously described (Tanumihardjo et al. 1996a). Finger prick capillary blood samples were collected into 500µl microtainer tubes (Becton Dickinson, Franklin Lakes, New Jersey, USA) three hours after administration of DRA. Height and weight of infants were also recorded using standard methods (United Nations Department of Technical Cooperation 1986).

Laboratory procedures

Blood and milk samples were immediately stored on ice in cool boxes and transported to the laboratory within two hours. Exposure to light was kept to a minimum. In the base laboratory, serum was immediately separated from whole blood and aliquots of serum and homogenised milk stored at -20oC in 2mL screw-top Nunc tubes. Frozen samples were transported to the Nutritional Intervention Research Unit of the Medical Research Council, Cape Town, South Africa, for analysis using standard HPLC procedures (Tanumihardjo & Penniston 2002;Valentine & Tanumihardjo 2004).

Data management and statistical considerations

Data were double-entered and daily cross checking routines used to detect and correct any discrepancies. Cleaned and locked database files were exchanged

for the treatment randomisation code, held by the data and safety monitoring board. Analyses were conducted, in a masked manner, according to a pre-agreed analytical plan using STATA version 7 (Stata Corp LP, College Station, Texas, USA). EPINut (EPI Info v6, Atlanta, GA, USA) was used to generate anthropometric indices. Prior to the study, a total of 780 six month old infants were estimated to provide 90% power to detect a relative decrease of one-third in the prevalence of VAD from 37% to 25%, at a 5% significance level.

The primary definition of VAD was an MRDR value ≥0.060 (i.e. the ratio of serum 3, 4-didehydroretinol (DR) to retinol (R) (DR/R)), three hours after the DRA dose was administered, and was evaluated in all randomised children with a valid laboratory result. As a secondary endpoint, VAD was also defined as a serum retinol concentration ≤0.70μmol/L and was considered severe at a concentration ≤0.35μmol/L. These and other categorical variables were compared using the chi-square test. Mean breast milk and serum retinol concentrations were compared using the t-test. Separate analyses evaluated endpoints at six and nine months of age. Safety was analysed by comparing the incidence rates of clinical signs of illnesses and diagnoses documented by the CSS during the 28 days after each supplementation and over all time at risk. Time at risk began from the time of recruitment and continued until the earliest of a clinical episode or censoring due to withdrawal, death or end of follow-up. Poisson regression models with random effects to take into account between-child heterogeneity were used to compare incidence rates. The proportions of participants with clinical signs of illnesses and symptoms detected actively within 48 hours after each supplementation were also compared. The effect of the intervention on anaemia and clinical malaria was evaluated by comparing incidence rates between the two groups. Anaemia was defined as either mild (a packed cell volume (PCV) <33%), severe (PCV<25%) or life threatening (PCV<15%). Anthropometric indices were assessed on all randomised infants at 6 and 9 months of age by comparing the proportion of infants in each group with a weight for age z-score (WAZ) <-2, height for age z-score (HAZ) <-2 and weight for height z-score (WHZ) <-2.

Quality Control

Standardised quality control procedures were used to ensure consistency in data collection and assessment of adverse events. Pre-coded forms with labels bearing identification information were used for all routine contacts. Training in the assessment of clinical signs of illness and monitoring of Clinical Officers and field workers was continued throughout the trial. Field activities were supervised through regular accompanied and repeated interviews. Vitamin A capsules for quality control were transported at regular intervals to the Institute of Nutritional Research, University of Oslo, Norway. These analyses confirmed that the 200,000 IU and100,000 IU capsules contained a satisfactory amount of retinyl palmitate throughout the trial period. The 25,000 IU capsules also had at least 80% potency up to July 2003, when the last dose of this type of capsule had already been given. The 50,000 IU capsules that were tested were also fully potent up to and including February 2003. However, between February and July 2003 the vitamin A content of the 50,000 IU capsules declined markedly, such that the 33 capsules that were analysed between August 2003 and January 2004 contained only 1,800-23,993 IU, with a mean of 15,861 IU, 32% the expected amount. Taking into consideration the results of similar analyses from a sister trial in Kintampo, Ghana, consensus was reached between the investigators, WHO and the trial Data and Safety Monitoring Board, before the code was broken, that the 50,00 0IU capsules in Ifakara degraded rapidly after May 2003. Hence, secondary statistical analyses were performed excluding the 5% of infants who received doses after 31st May 2003, and tertiary analyses excluding the 30% of infants who received doses after 31st January 2003. In addition, assessments of both efficacy and safety were evaluated taking into consideration the time elapsed since the date that recruitment started, using the Likelihood Ratio test comparing a model with the effect of the vitamin A with a model where the cohort had been split into tertiles of date of recruitment and looking for an interaction between the date of recruitment tertile and efficacy.

6.4 Results

Recruitment of 780 mother-infant pairs took from April 2002 to March 2003, and follow-up was completed by the end of 2003. Completeness of follow-up (figure 2) and baseline characteristics (table 1) were similar in the two groups.

The incidence of all clinical signs of illnesses, symptoms and diagnoses detected by the CSS was similar in the two groups of infants during the 28 days after each supplementation (data not shown) and during all time at risk (table 2). Active case detection documented a lower prevalence of fever after the first dose of vitamin A given to infants in the higher dose arm (147/308 (48%)) versus the lower dose arm (183/318 (58%), risk ratio 0.83 (95% confidence interval (CI) 0.71, 0.96), p=0.01). No similar pattern was seen after other doses and the prevalence of other signs and symptoms (e.g. fits, jaundice, and chest in drawing) was similar after all doses (data not shown).

The proportion of infants with inadequate vitamin A liver stores (MRDR ≥0.060) at 6 months was 43% in the higher and 47% in the lower dose arm (table 3). Vitamin A deficiency of different severities, defined according to serum retinol, and mean serum retinol concentrations were also similar in the two groups.

Table 1: Baseline characteristics of children and mothers

		Vitamin A Supplementation Group				
		Higher Dose (N=390)		Lower Dose (N=390)		
Variable		n	%	n	%	p-value
Male		215	55	197	51	0.20*
Exclusive breastfeeding at age one month		337	86	338	87	0.92 *
VAD (mRDR≥0.06) before child's first dose		255	84	238	82	0.44 *
Maternal education	None	61	16	71	18	
	Primary	314	81	301	77	
	Secondary	15	4	18	5	0.52 *
Distance from hospital (km)	1st tertile	112	34	124	37	
	2nd tertile	112	34	107	32	
	3rd tertile	108	33	100	30	0.60 *
Insecticide Treated Net use		334	86	337	86	0.76 *

	Mean	SD	Mean	SD	p-value
Age at Dose 1 (months)	1.41	0.96	1.38	0.89	0.68#
Mean birth weight (Kg)	2.94	0.46	2.90	0.76	0.33 #
Serum retinol (µmol/L) before child's first dose	0.67	0.19	0.67	0.18	0.76 #
Breast milk retinol(µmol/L) after delivery	4.34	3.01	4.60	3.52	0.34 #

The incidence of malaria and anaemia during follow up, and the cross-sectional prevalence of anaemia and malaria, and anthropometric indices, were similar in the two groups (table 4).

The secondary and tertiary analyses excluding data from children receiving vitamin A supplements after May 31st 2003 and January 2003, respectively, did not significantly change these results (data not shown).

Table 2: Incidence o signs and symptoms detected by clinical surveillance system from recruitment to end of time at risk

Outcome	Higher Dose			Lower Dose			Comparison		
	Episodes	PYAR	Rate	Episodes	PYAR	Rate	RR	95%CI	p-value
Fever	739	197.8	3.74	768	195.6	3.93	0.95	(0.83, 1.08)	0.44
Runny Nose	451	208.4	2.16	478	206.7	2.31	0.94	(0.79, 1.12)	0.47
Diarrhoea	272	222.6	1.22	288	222.6	1.29	0.95	(0.79, 1.15)	0.59
Vomiting	120	234.0	0.51	138	233.5	0.59	0.87	(0.67, 1.13)	0.29
Coughing	741	186.4	3.98	798	183.1	4.36	0.91	(0.79, 1.04)	0.17
Fast breathing	28	240.6	0.12	27	241.6	0.11	1.01	(0.55, 1.85)	0.97
Fitted	2	242.6	0.01	3	243.3	0.01	0.67	(0.11, 4.00)	0.66
Pallor	13	241.9	0.05	12	242.7	0.05	1.07	(0.47, 2.45)	0.87
Jaundice	0	242.7	0	2	243.3	0.01	.	.	.
Nasal flaring	76	237.1	0.32	74	237.9	0.31	1.01	(0.72, 1.44)	0.93
Chest indrawing	164	230.3	0.71	159	232.0	0.69	1.02	(0.80, 1.30)	0.85
Pus in ears	19	241.3	0.08	28	241.4	0.12	0.67	(0.35, 1.28)	0.23
Bulging fontanelle	0	242.7	0	0	243.4	0	.	.	.
Wheezing	230	225.2	1.02	243	225.1	1.08	0.95	(0.76, 1.17)	0.62
Stiff Neck	5	242.4	0.02	4	243.2	0.02	1.25	(0.34, 4.67)	0.74
Hepatomegaly	8	242.2	0.03	3	243.2	0.01	2.68	(0.71,10.09)	0.15
Splenomegaly	95	235.5	0.4	86	236.9	0.36	1.11	(0.83, 1.49)	0.48
Oedema	6	242.2	0.02	3	243.2	0.01	2.01	(0.50, 8.03)	0.32
Oral candidiasis	1	242.7	0	1	243.3	0	1	(0.06,16.03)	1
Chest crackles	363	215.5	1.68	369	216.1	1.71	0.99	(0.82, 1.18)	0.88

Table 3: Prevalence of vitamin A deficiency and mean serum retinol concentration at 6 and 9 months

Outcome	Higher dose % (n/N)	Lower dose % (n/N)	Relative Risk (95% CI)	p value
6 months				
mRDR≥0.06	43 (125/293)	47 (132/282)	0.91 (0.76,1.09)	0.32*
Serum retinol ≤0.70µmol/l	36 (111/306)	41 (121/296)	0.89 (0.73,1.09)	0.25*
Serum retinol ≤0.35µmol/l	1 (3/306)	2.4 (7/296)	0.41 (011,1.59)	0.18*
Mean serum retinol µmol/l (SD)	0.79 (0.24)	0.81 (0.25)	-	0.16Ŧ
Mean breast milk retinol µmol/l (SD)	1.82 (1.09)	1.88 (1.09)	-	0.49Ŧ
9 Months				
mRDR≥0.06	41 (113/278)	40 (108/269)	1.01 (0.83,1.24)	0.91*
Serum retinol ≤0.70µmol/l	29 (85/292)	32 (90/286)	0.93 (0.72,1.18)	0.54*
Serum retinol ≤0.35µmol/l	1.7 (5/292)	1.8 (5/286)	0.98 (0.29,3.35)	0.97*
Mean serum retinol µmol/l (SD)	0.86 (0.32)	0.90 (0.36)	-	0.16Ŧ
Mean breast milk retinol µmol/l (SD)	1.86 (1.19)	1.95 (0.97)	-	0.33Ŧ

* Chi-squared test, Ŧ t-test

Table 4: Anthropometric, malaria and anaemia indices

Outcome	Higher Dose		Lower Dose		Relative Risk (95% CI)	p-value
	n/N	%	n/N	%		
Prevalence at 6 months of age						
WAZ[1] <-2	12/305	3.9	15/289	5.2	0.76 (0.36,1.59)	0.46
HAZ[2] <-2	29/309	9.4	18/297	6.1	1.55 (0.88,2.73)	0.13
WHZ[3] <-2	3/304	1.0	7/289	2.4	0.41 (0.11,1.56)	0.17
Moderate anaemia†	125/311	40.2	121/304	39.8	1.01 (0.83,1.23)	0.92
Severe anaemia‡	3/311	1.0	3/304	1.0	0.98 (0.20,4.81)	0.98
Prevalence at 9 months of age						
WAZ[1] <-2	38/287	13.2	43/272	15.8	0.84 (0.56,1.25)	0.39
HAZ[2] <-2	39/297	13.1	31/279	11.1	1.18 (0.76,1.84)	0.46

WHZ[3] <-2	12/298	4.2	12/271	4.4	0.94 (0.43,2.06)	0.88
Moderate anaemia†	87/298	29.2	89/288	30.9	0.94 (0.74,1.21)	0.65
Severe anaemia‡	5/298	1.7	5/288	1.7	0.97 (0.28,3.30)	0.96
Incidence during all time at risk after recruitment						
	Events /PYAR	Incidence	Events /PYAR	Incidence	Incidence Rate Ratio	p-value
First malaria episode	46/240.4	0.19	37/242.1	0.15	1.25 (0.81,1.93)	0.31
First mild anaemia episode	50/241.2	0.23	45/241.3	0.19	1.11 (0.74,1.66)	0.61

1: weight for age z-score, 2: height for age z-score, 3: weight for height z-score, †Packed Cell Volume <33%, ‡Packed Cell Volume <25%, PYAR-person years at risk

6.5 Discussion

This double-blind randomised controlled trial has shown that supplementation of mothers with a second dose of 200,000IU of vitamin A, and their infants with 50,000IU at the time of routine vaccinations at approximately 1, 2 and 3 months of age, was safe but not efficacious compared to a lower dose regimen. Biochemical markers of vitamin A status were similar in infants in both arms at 6 and 9 months of age, as were mean breast milk retinol concentrations. Clinical endpoints detected passively and actively did not suggest any consistent clinical benefits of the higher dose regimen.

These results are not what had been expected (Humphrey & Rice 2000) and it is important to consider all possible explanations. The degradation of vitamin A capsules, which was most marked in the 50,000IU capsules, is a prime concern. However, the analyses excluding children who may have been dosed with lower amounts of vitamin A than intended reassured us that the deterioration of the capsules was not the reason for the lack of efficacy of the intervention. This finding shows the importance of the quality control assessments that were included in this clinical trial, and emphasises the importance of such checks both in future clinical trials and in routine supplementation programmes.

Another possibility is that the measures of VAD used in this study do not accurately reflect the vitamin A status of the very young African infants involved. Young infants are subject to major physiological changes and a high incidence of infectious

disease. The integrity of serum retinol as a measure of VAD may be compromised, for example, by elevated acute phase proteins resulting from infections, leading to an under-estimate of serum retinol concentration (Thurnham et al. 2003) and reducing the specificity of serum retinol as a marker of VAD. This would tend to downwardly bias efficacy estimates based on this measure. However, MRDR tests were used as the primary outcome measure and are not affected by sub-clinical inflammation (Tanumihardjo et al. 1996b;Wieringa et al. 2002). We collected blood samples for MRDR evaluation three hours after DRA dosing. However, it is now clear that samples should be collected at least four hours after supplementation as earlier sampling reduces the sensitivity of the test. Although this would reduce the power of our study, we nevertheless found a high prevalence of VAD and thus conclude that the timing of MRDR blood sample collection is unlikely to explain the lack of efficacy in this study. The gold standard measure of vitamin A status requires a liver biopsy, an investigation too invasive for a trial such as this. The MRDR test is the most appropriate indicator of vitamin A status and has been shown to work well in older populations when the test is tightly controlled and care taken with its interpretation. However, its use in field settings involving young African infants merits further investigation.

The study was not placebo controlled because it was not considered ethical to randomise some infants to placebo when the lower dose regimen had been shown to have a marginal beneficial effect in a previous trial. Hence, our efficacy estimate may be slightly lower than would have been the case had this been a placebo-controlled trial. Nevertheless, the prevalence of VAD in the two arms was high and very similar: it seems unlikely that we missed a substantial effect of the higher dose regimen.

The study benefited from the availability of a Clinical Surveillance System (CSS) which generated detailed clinical safety and efficacy information. The data generated by this passive case detection system was qualitatively different from that generated by the active case detection used to detect any immediate, short term side effects of the supplementation. The CSS documented episodes of illness that were severe enough for a child to be brought to the clinic, and covered the whole nine months of follow up for each infant rather than just two days after supplementation. The fact that there was no increase in either the short term side-effects or passively detected

illnesses, including bulging fontanelle, provides reassurance that the higher dose regimen was as safe as the lower dose regimen. However, the lack of any decrease in incidence of illnesses detected through the CSS suggests that the higher dose regimen did not confer any important absolute effect on morbidity.

The best approach to improve the vitamin A status of young infants remains unclear. It may be that even higher doses of vitamin A at the time of routine vaccinations, and/or to mothers of young children, would have an impact. Alternatively, given the success of immunisation campaigns to raise vitamin A supplementation coverage, it may be useful to assess the effects of these on vitamin A status and to consider supplementing children aged less than six months in such campaigns. Another approach would be to further evaluate the effects of early neonatal supplementation.

The higher dose supplementation regimen we evaluated has already been recommended by the International Vitamin A Consultative Group (International Vitamin A Consultative Group (IVACG) 2002). Although not previously tested in a clinical trial, the recommendation was based on theoretical calculations of its likely effect on infants' vitamin A status, the potential for reductions in infant morbidity and mortality and a low probability of any important toxic side effects. Our results do not support this current IVACG recommendation. This highlights the difficulties inherent in balancing the urgency of reducing high infant mortality rates by implementing interventions that seem likely to be beneficial, against the time taken to conduct appropriate studies to gain empirical evidence of their efficacy. However, the EPI offers unparalleled opportunities to deliver health interventions to infants, the age group of children who suffer the highest mortality rates, and it is essential that the safety and efficacy of any potential intervention are tested in carefully conducted clinical trials before being implemented.

In conclusion, higher dose vitamin A supplementation was well tolerated by mothers and infants, but failed to improve the vitamin A status or the incidence of illness episodes in trial participants. The stability of the vitamin A capsules is of great concern and draws attention to the need for quality assurance checks on such capsules in clinical trials and routine supplementation programmes. Specific validation of the biochemical indicators of vitamin A status may be useful in very

young infants. This study highlights the potential dangers of basing policy recommendations on theoretical calculations and plausible extrapolation from existing empirical data.

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CHAPTER 7: Vitamin A supplementation in Tanzania: The impact of a change in programmatic delivery strategy on coverage

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7.1 Abstract

Background

Efficient delivery strategies for health interventions are essential for high and sustainable coverage. We report impact of a change in programmatic delivery strategy from routine delivery through the Expanded Programme on Immunization (EPI+) approach to twice- yearly mass distribution campaigns on coverage of vitamin A supplementation in Tanzania

Methods

We investigated disparities in age, sex, socio-economic status, nutritional status and maternal education within vitamin A coverage in children from two independent household level child health surveys conducted: 1) prior to the introduction of twice-yearly mass distribution campaigns (1999); and 2) three years later (2002). A representative cluster sample of approximately 2,400 rural households was obtained from Rufiji, Morogoro Rural, Kilombero and Ulanga districts. A modular questionnaire about the health of all children under the age of five was administered to consenting heads of households and caretakers of children. Information on the use of child health interventions including vitamin A was asked.

Results

Coverage of vitamin A supplementation among 1- 2 year old children increased from 13% [95% CI 10-18%] in 1999 to 76% [95%CI 72-81%] in 2002. In 2002 knowledge of two or more child health danger signs was negatively associated with vitamin A supplementation coverage (80% versus 70%) (p=0.04). Nevertheless, we did not find any disparities in coverage of vitamin A by district, gender, socio-economic status and DPT vaccinations.

Conclusions

Change in programmatic delivery of vitamin A has been shown to achieve a major improvement in coverage in Tanzania that has been sustained by repeated campaigns for at least three years. There is a need to monitor the

effect of such campaigns on the routine health system and on equity of coverage. Documentation of vitamin A supplementation campaign contacts on routine maternal and child health cards would be a simple step to facilitate this monitoring.

7.2 Background

Vitamin A supplementation is one of the best proven, safest and most cost-effective interventions in public health (World Bank 1993). In populations where vitamin A deficiency is of public health importance (WHO 1998), vitamin A supplements are recommended as prophylaxis and as treatment for at-risk groups and sick individuals respectively. Approximately two- thirds (Jones et al. 2003) of the 10.8 million child deaths (Ahmad, Lopez, & Inoue 2000) that presently occur can be prevented by available interventions of which vitamin A supplementation (VAS) is one. A meta-analysis of several large vitamin A trials has shown that improving vitamin A status reduces mortality rates between 23-34% among children six months to five years of age if vitamin A supplementation is given at least twice per year at coverage rates of at least eighty percent (Beaton et al. 1993;Fawzi et al. 1993).

In Tanzania, efforts to combat vitamin A Deficiency (VAD) through supplementation started through a disease-targeted approach in 1987. This was not very successful because it was confined to government-owned primary health care facilities and targeted therapeutically to children between 6-59 months suffering from xerophthalmia or diseases precipitating VAD. Consequently, many young children at risk of VAD in Tanzanian communities were not supplemented with vitamin A through this approach. In 1997, Vitamin A supplementation was introduced through the routine Expanded Programme on Immunization (EPI) for post partum mothers' and children at 9 months together with measles vaccination.

During measles vaccine campaigns in late 1999 and 2000, children between 6-59 months from 30 and 52 districts respectively of mainland Tanzania also received vitamin A supplements. Post campaign Vitamin A supplementation

coverage levels in these pilot campaigns were estimated at 94% and 99% in 1999 and 2000 respectively (Mugyabuso JKL. paper presented at the Annual EPI evaluation meeting 2002). Based on these results and similar lessons from the Philippines (Fiedler et al. 2000), UNICEF initiated and supported the national bi-annual implementation of VAS in children 6 months to 5 years in Tanzania starting in 2001. Advocacy, social mobilization and campaigns through national mass media agencies were used to create awareness in communities. The estimated coverage for targeted children in June and December 2001 from routine statistics was 80% and 91% respectively (Mugyabuso JKL, paper presented at the Annual EPI evaluation meeting 2001).

Here we describe the effect of the change in programmatic delivery strategy of vitamin A supplementation on coverage as documented through two independent household-level child health surveys carried out prior to the introduction of the twice-yearly mass distribution strategy (1999) and three years later (2002). We also describe factors associated with access to the intervention.

7.3 Methods

This study was part of a larger evaluation of the effectiveness and cost of health system and facility-based Integrated Management of Childhood Illness (IMCI). Details of the study area have been described elsewhere (Armstrong Schellenberg et al. 2003). In brief, Rufiji and Kilombero districts are low-lying and much of the land has fertile alluvial soil of the Rufiji and Kilombero River plains respectively. Morogoro Rural and Ulanga are mountainous with some low-lying areas. The main economic activities of the population are subsistence farming and fishing. The four districts have an estimated total population of about 1.2m people (Tanzania National Bureau of Statistics 2003). Morogoro Rural district participated in the 1999 but not the 2000 measles campaign which also included pilot vitamin A supplementation. Kilombero district participated only in 2000 measles campaign. Rufiji and Ulanga districts were not part of either pilot campaign.

A representative cluster sample of approximately 2,400 rural households was obtained from the four districts. In 1999, 30 clusters were selected from each of three districts and 35 clusters from Kilombero District. Villages (clusters) were selected with probability proportional to size, and one kitongoji (sub-village with approximately 100 households) was selected at random from each selected village. 20 households were selected using a modified EPI-type scheme (Bennett et al. 1991) that guaranteed an equal probability of selection for every household. In 2002, the same villages were selected but the sampling of sub-villages and households was repeated with replacement. The chances of visiting the same households were small. Ifakara town in Kilombero district is the largest urban area in the survey; ten additional clusters from this town have been omitted from the analysis described here, so that all results refer to rural areas.

A structured questionnaire about the health of all children under the age of five years was administered to consenting heads of the households. We documented background information of all children in the household, information on proxy indicators of household socio-economic status such as household ownership of a radio, a tin roof, a bicycle, educational level and occupation of the head of household. Mothers or caretakers of children were interviewed about their educational level and knowledge of child health danger signs (fast breathing, difficult breathing, fits or convulsions, very sleepy, vomiting all ingested material or inability to drink or breastfeed). Vaccination history was recorded from health cards or mother's record books for those who had one. Where there were no records or none could be found, mothers or caretakers were asked whether the child had DPT immunizations and the number of doses received. Mothers or caretakers of the children were shown a vitamin A capsule and were asked whether their children had ever received a similar one, and if so, the month and year of the most recent dose.

Data analysis

Data were double-entered and verified using FoxPro (version 2.6, Microsoft Corporation, Seattle, WA, USA) at Ifakara Health Research and Development

Centre (IHRDC). Range checks and internal consistency were performed before analysis in Stata (version 8.2, Stata Corporation, College Station, TX, USA).

The analysis took into account the clustered nature of data. We used standard STATA svy*tab* command to produce design-based F-tests. Vitamin A supplementation coverage was defined as the number of children between 1 and 2 years of age receiving vitamin A in the six months prior to the date of the survey divided by the total number of children between 1 and 2 years in the survey (Victora, Bryce, & Lambrechts 1998). A relative index of socio-economic status was constructed by combining documentation of household characteristics, assets, income sources and education. We used principal components analysis to estimate the appropriate weights or "scores" for the index (Filmer & Pritchett 2001). Quintiles of children were developed based on their household socio-economic score.

7.4 Results

A total of 385 and 388 children aged between 1 and 2 years who had complete data on vitamin A supplementation were sampled from 2,131 and 2,027 households in 1999 and 2002 surveys respectively. Table 1 shows selected background of the study subjects from the two surveys. Approximately 1% (1999) and 0.4% (2002) of the households refused to participate in the surveys.

Overall coverage of vitamin A increased from 13.2% [95% CI: 9.8-17.7%] in 1999 to 76.3% [95% CI: 71.5-80.5%] (Table 2). As expected, maternal education was associated with VAS coverage, although the difference reached conventional statistical significance only in 1999 (p=0.02), and not in 2002 (p=0.08). Coverage of VAS was similar in the two surveys for both boys and girls and did not vary by vaccination status. However, in the 2002 survey, maternal knowledge on child health danger signs was found to be negatively associated with VAS coverage, which was about 10 percentage points lower in mothers who knew at least two danger signs than in those who did not. The

VAS achieved a major increase in coverage without any decrease in equity: coverage was uniformly distributed by socio-economic status before and after the campaigns, as well as across the districts.

7.5 Discussion

This study has revealed that a change in the delivery strategy of interventions in a health system can have important effects on coverage without compromising equity. Our data has shown that, vitamin A supplementation coverage in children between 1 and 2 years of age increased from 13% in 1999 to 76% in 2002. National coverage figures from the 1999 Tanzania Reproductive and Child Heath Survey (TRCHS) were similar (14%) (Tanzania National Bureau of Statistics & Macro International Inc.Calverton 2000) to what we observed in study districts. However, more recent national coverage estimates from the 2004/2005 DHS, which include around 7,000 children (Tanzania National Bureau of Statistics & Macro International Inc.Calverton 2005), are rather lower, at (46%), than we found in our 2002 survey, possibly due to geographic variations in coverage or to a drop between 2002 and 2004. In contrast, 85% and 90% coverage at national level have been recently reported by two other sources (Ndossi, G.D. 2004 and Helen Keller International, 2004), the second of which was population based assessment in 12,000 children from 21 regions of mainland Tanzania. The most likely explanation for the discrepancies between the 2004/05 DHS and HKI survey, both of which cover the entire country are a combination of survey timing and differences in questionnaires wording and implementation. The HKI survey was conducted during early to end of August 2004, and had a short recall period, as it was little more than a month after the June 2004 VAS campaign. The DHS was conducted from October 2004 to January 2005. Further, the HKI survey question on VAS had a specific point reference of June 2004 whereas the DHS question referred to a 6 month period prior to the survey (giving the scope to capture VAS provided through EPI+ as well as disease targeted approaches, which would have increased coverage estimates). Interview techniques, whether or not mothers were actually shown the

capsules, and whether the capsules were of the right colour, could explain the differences observed (Mugyabuso, report in preparation). Sampling methodology also differed between the surveys.

We found no worsening of inequities in vitamin A supplementation between 1999 and 2002, despite the major increase in coverage, unlike what has been reported elsewhere (Choi, Bishai, & Hill 2005). Introduction of new health interventions is often embraced by richest first and followed gradually by the poorest (Victora et al. 2000). As our data shows one would expect equity to get worse as coverage increases, before it can get better. Here we found the opposite and highlights the need for devising ways to maintain these achievements (Mills 2005). We did not find any evidence of gender or district differentials in VAS coverage. A negative association between vitamin A supplementation and maternal knowledge of child health danger sign was rather unexpected. We think this to be more of a chance finding than a real difference.

Vitamin A supplementation campaigns in Tanzania have been concerted efforts by the Government and stakeholders from the health sector. To maximize coverage, activities were strategically integrated into commemoration of the Day of the African Child and World AIDS Day events. During implementation, partnerships were forged between the Presidents Office for Regional Administration and Local Government (PORALG), Ministry of Health and the Tanzania Food and Nutrition Centre (TFNC). Funding support came primarily from UNICEF and vitamin A supplies from Canadian International Development Agency (CIDA). Other agencies and Non Governmental Organizations such as USAID and Plan International also joined these efforts, albeit in later rounds.

This study had two potential limitations. First, we depended largely on the mothers' or caretakers' accounts of the vitamin A supplementation status of their children. We also checked the child's MCH card or notebook for information about vitamin A supplementation but this had limited use as the campaign staff were trained not to record the vitamin A dose on the children's health cards. Secondly, neither the 1999 nor the 2002 household surveys

were designed solely to evaluate the change in delivery strategy or policy, but were rather designed to measure coverage of various interventions for children under five, vitamin A supplementation being one, as recommended by UNICEF and WHO (Victora, Bryce, & Lambrechts 1998).

Although the bi-annual campaign-based strategy for vitamin A delivery resulted in a major increase in coverage, it remains important that this approach sustains universal coverage while not undermining routine health programs (Schreuder & Kostermans 2001).

One among the many obstacles for health systems in low-income countries is fragmented health information systems. Reliable and timely health information is an essential foundation for public health action. Such systems are vital for informing decision-makers to enable them to identify problems and needs, track progress, evaluate the impact of interventions, and make evidence-based decisions on health policy and effect policy change. Routine health programs may be weak due to poor motivation, often overburdened health staff with excessive data and reporting from multiple data collection systems and lack of supervision. The VAS coverage rates that we have observed so far in Tanzania need to be sustained and monitored regularly if we are to reach the MDGs in 2015. The MCH “Road to Health” cards offer a practical opportunity to capture information on interventions that children actually receive through routine systems or campaigns.

During the mass distribution campaigns, vitamin A supplementation was not recorded on the health card. If campaigns are going to continue, monitoring of progress would be greatly simplified if planners ensure that information for each individual child is recorded. To our knowledge, vaccines or vitamin A supplementation campaigns that are outside routine EPI are not generally registered on children’s health cards.

Coverage figures of the campaigns since 2001 have been recorded on tally sheets and subsequently summary sheets that were later collated by Tanzania Food and Nutrition Centre. The problem with this approach is the

potential to over-estimate coverage because of lack of proper denominators, or inflated numerators due to multiple doses to the same children. Documenting any extra contacts such as National Immunization Days (NID) or other related health events on health cards not only offers a useful opportunity to reliably estimate coverage figures, but also creates a less demanding and more integrated health information system. In our study, we used information provided by mothers as well as that written on health cards to estimate coverage figures. This source of information is also open to error but is likely to be a conservative estimate, and has the advantage of being household-based (Murray et al. 2003).

Social mobilization campaigns are good for catch-up coverage over a short period of time. This coverage has been sustained for at least three years. In spite of the campaigns, National VAS coverage has dropped to 46% in 2004 (Tanzania National Bureau of Statistics & Macro International Inc.Calverton 2005). Given the evidence on the cost per death averted in Tanzania (MOST & USAID Micronutrient Program 2005) and the role vitamin A can play in reducing child mortality, allocation of resources required to implement such child health interventions need to be maintained.

We conclude that, since routine services at present are not geared towards monitoring vitamin A supplementation campaign contacts, deliberate efforts must be taken to enable capturing of such information at both routine contacts and campaigns. This will facilitate the monitoring of the effect of campaigns on routine health systems, equity of coverage and tracking progress on child survival.

List of abbreviations

EPI Expanded Programme on Immunization

DPT Diphtheria Pertussis, Tetanus

VAS Vitamin A Supplementation

VAD Vitamin A Deficiency

UNICEF United Nations Children Education Fund

IMCI Integrated Management of Childhood Illnesses

IHRDC Ifakara Health Research and Development Center

TRCHS Tanzania Reproductive and Child Health Survey

TFNC Tanzania Food and Nutrition Center

PORALG Presidents Office for Regional Administration and Local Government

AIDS Acquired Immune Deficiency Syndrome

CIDA Canadian International Development Agency

USAID

MCH Maternal and Child Health

WHO World Health Organization

NID National Immunization Day

Competing interests

None declared

Authors' contribution

HM conceived the idea and participated in the design of the study, conducted the analysis and writing the manuscript. JAS participated in conceiving the idea, study design, coordination of the study and writing the manuscript. DdS participated in the design of the study and writing the manuscript. HMM participated in the coordination of the study and writing the manuscript. MS, JKLM and GDN participated in writing the manuscript. All authors read and approved the manuscript.

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Table 5: Distribution of selected characteristics in 1999 and 2002 survey

Characteristics	Survey year			
	1999		2002	
Sex (N=385 in 1999, 388 in 2002)				
Female	197	51.2	183	47.2
Male	188	48.8	205	52.8
Age distribution‡				
6-11 months	467	25.2	401	21.3
1-2 years	385	20.7	388	20.6
2-3 years	353	19.0	406	21.6
3-4 years	348	18.7	356	19.0
4-5 years	304	16.4	330	17.5
DPT vaccination (N=385 in 1999, 387 in 2002)				
Not vaccinated	105	27.3	91	23.5
Vaccinated	280	72.7	296	76.5
Mothers education (N=385 in 1999, 388 in 2002)				
None	129	33.5	100	25.7
Primary	243	63.1	280	72.2
Secondary/Higher	13	3.4	8	2.1
Knowledge of ≥2 danger signs (N=353 in 1999, 375 in 2002)				
No	281	79.9	244	65.1
Yes	71	20.1	131	34.9
Wealth quintiles (N=350 in 1999, 376 in 2002)				
Poorest	60	17.1	73	19.4
Second poorest	56	16.0	77	20.5
Middle	80	22.9	70	18.6
Second richest	73	20.9	82	21.8
Richest	81	23.1	74	19.7
District (N=385 in 1999, 388 in 2002)				
Morogoro	79	20.5	95	24.5
Rufiji	99	25.7	108	27.8
Ulanga	111	28.8	114	29.4
Kilombero	96	25.0	71	18.3

‡ All children under five year included here

Table 6: Vitamin A supplementation coverage in children (12-23) months by selected characteristics

Characteristics	1999 Survey					2002 Survey				
	n	N	%	95%CI	p value[a]	n	N	%	95%CI	p value[a]
VAS coverage										
All districts	51	385	13.2	9.8-17.7		296	388	76.3	71.5-80.5	
Sex										
Male	27	188	14.4	9.8-20.5	0.53	161	205	78.5	71.9-83.9	0.28
Female	24	197	12.2	7.9-18.4		135	183	73.8	66.8-79.7	
DPT vaccination										
Vaccinated	37	280	13.2	9.5-18.1	0.97	229	296	77.4	71.6-82.3	0.34
Not vaccinated	14	105	13.3	7.6-22.3		66	91	72.5	63.2-80.2	
Maternal education										
No	10	129	7.8	4.2-13.8		70	100	70.0	60.2-78.3	
Primary	37	243	15.2	11.2-20.3	0.02	218	280	77.9	72.4-82.5	0.08
Secondary	4	13	30.8	12.0-59.1		8	8	100.0	-	
Knowledge of ≥2 danger signs										
No	35	282	12.4	9.1-16.8	0.09	195	244	79.9	74.4-84.5	0.04
Yes	14	71	19.4	11.5-31.8		91	131	69.5	60.0-77.6	
Socio-economic status										
Poorest	5	60	8.3	3.7-17.8		56	73	76.7	67.5-84.0	
Very Poor	10	56	17.9	9.6-30.9		59	77	76.6	65.5-85.0	
Poor	9	80	11.3	5.7-21.1	0.64[b]	49	70	70.0	56.7-80.6	0.68[b]
Less Poor	10	73	13.7	6.7-26.0		65	82	79.3	68.7-86.9	
Least Poor	12	81	14.8	8.1-25.5		58	74	78.4	67.6-86.3	
District										
Morogoro	12	79	15.2	8.2-26.5		73	95	76.8	66.9-84.5	
Rufiji	13	99	13.1	6.6-24.3	0.85	81	108	75.0	65.3-82.7	0.94
Ulanga	16	111	14.4	8.4-23.6		89	114	78.1	69.3-84.9	
Kilombero	10	96	10.4	5.5-18.9		53	71	74.6	61.6-84.4	

CHAPTER 8: Effectiveness and cost of facility-based Integrated Management of Childhood Illness (IMCI) in Tanzania

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8.1 Summary

Background

The Integrated Management of Childhood Illness (IMCI) strategy is designed to address major causes of child mortality at community, health facility, and health system levels. We aimed to evaluate the effectiveness of facility-based IMCI in rural Tanzania.

Methods

We compared 2 districts with facility-based IMCI and 2 neighbouring comparison districts without IMCI, from 1997 to 2002, using a non-randomised study. We assessed quality of case-management for child illness, drug and vaccine availability, and supervision involving case-management, through a health facility survey in 2000. Household surveys were used to assess child health indicators in 1999 and 2002. Child survival was tracked through demographic surveillance over a pre-defined 2-year period from mid-2000. Additional information on contextual factors was gathered through interviews and record review. The economic cost of child health care in IMCI and comparison districts was estimated through interviews and record review at national, district, facility and household levels.

Findings

During the IMCI phase-in period, under-five mortality rates were almost identical in IMCI and comparison districts. Over the two following years, mortality levels were 13% lower in IMCI than comparison districts (95% CI –7%, 30% or 5%, 21%, depending on how adjustment is made for district-level

clustering), with a rate difference of 3.8 fewer deaths per 1000 children per year. Contextual factors, such as mosquito net use, all favoured the comparison districts. Costs of child health care were comparable or lower with IMCI than with case-management without IMCI.

Interpretation

Our findings support going to scale through widespread implementation of facility-based IMCI in the context of health sector reform, basket funding, good facility access and high utilization of health facilities.

8.2 Introduction

Every year, more than ten million children worldwide die (Black, Morris, & Bryce 2003), and 95% of these deaths occur in just 42 less developed countries. The inequity in children's survival between rich and poor countries is unacceptably vast, as are the differences in survival between richer and poorer children within most countries (Victora et al. 2003). Although children's survival worldwide has improved over the past 30 years, the rate of increase peaked around 1980 and there has been virtually no further improvement since then in sub-Saharan Africa. In some countries, children's survival has even declined, and HIV/AIDS is only a partial reason (Walker, Schwartlander, & Bryce 2002). The main causes of death of children worldwide are neonatal disorders, diarrhoea, pneumonia, and malaria, although HIV/AIDS accounts for at least 10% of deaths in some African countries (Black, Morris, & Bryce 2003). Undernutrition is a major underlying cause and has been estimated to

contribute to more than half of all deaths in children (Black, Morris, & Bryce 2003).

Effective interventions are available that could prevent more than 60% of all deaths in children (Jones et al. 2003). Yet mothers and children are not receiving these interventions: coverage remains unacceptably low (Bryce et al. 2003). The Integrated Management of Childhood Illness (IMCI) is a strategy for improving children's health and development through the combined delivery of essential child-health interventions. Originally, IMCI consisted of case management guidelines for sick children in peripheral first-level health facilities, to be adapted for each country (Gove 1997). Later, the strategy expanded to include guidelines from WHO and UNICEF for delivering interventions to increase children's survival at household, community, and referral levels, with three components: improvements in case-management; improvements in health systems; and improvements in family and community practices. By the end of 2003, the first two components of IMCI were in the early implementation or expansion phase in 108 less developed countries, including virtually all African countries south of the Sahara (WHO 2004). The Multi-Country Evaluation of IMCI seeks to generate information on the effectiveness, cost, and impact of IMCI that can be used to strengthen the delivery of child-health interventions and the implementation of the IMCI strategy; it includes in-depth studies in Bangladesh, Brazil, Peru, Tanzania, and Uganda (Bryce et al. 2004). In Tanzania, the mortality among children younger than 5 years is 147 per 1000 births, resulting in almost 250 000 deaths each year (National Bureau of Statistics & Macro International Inc

2000). The country has a gross domestic product of US$501 per head (UNDP 2001) and is undergoing health-sector and local-government reforms. As districts gain more control over their health budgets, IMCI is one of the strategies recommended by the Ministry of Health to address major children's health problems such as malaria, pneumonia, malnutrition, and diarrhoea, which together account for more than 83% of postperinatal deaths before the age of 5 years (unpublished data from the Tanzania Essential Health Interventions Project). Here, we report the effectiveness of facility-based IMCI, by which we mean the first two components of the strategy, on children's health and survival in rural Tanzania.

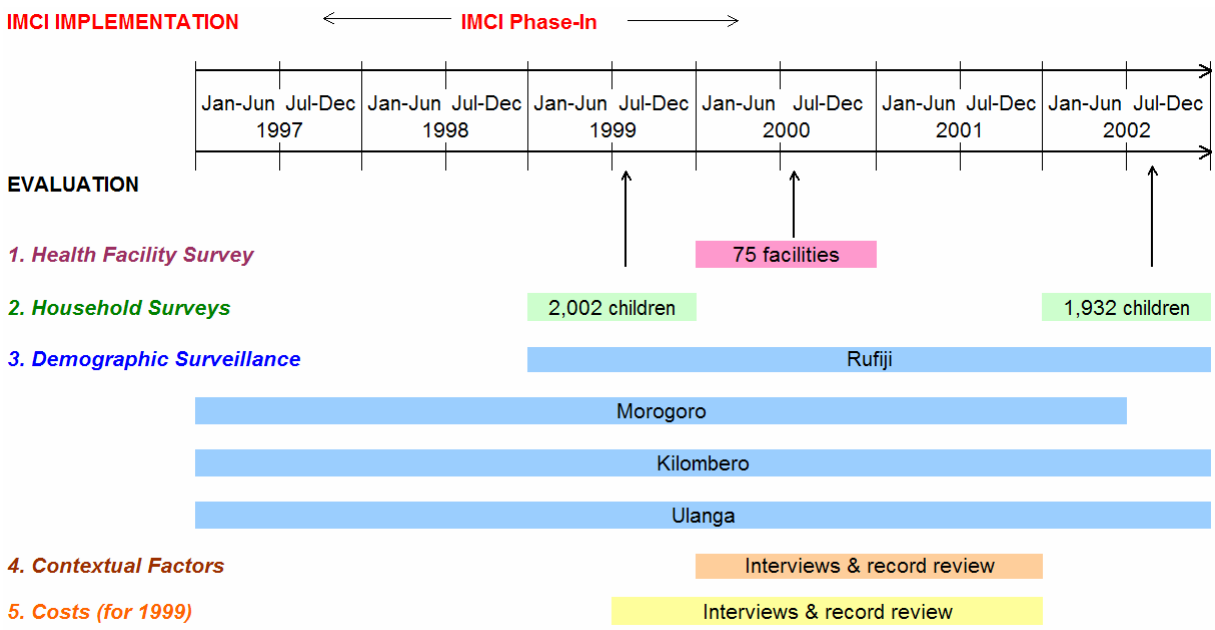

Figure 7: Timing of implementation of IMCI and the different components of this study

We compared children's health, behaviours at household level relating to children's health, and children's survival in two districts with facility-based

IMCI and two neighbouring comparison districts without IMCI over the period from 1997 to 2002.

8.3 Methods

Design

We used a non-randomised controlled trial, or "plausibility" design (Habicht, Victora, & Vaughan 1999), in which there is monitoring of process measures to improve the internal validity of the study and of contextual factors to check whether any apparent effect of the intervention is due to other factors. We compared children's health and survival in four neighbouring rural districts of Morogoro and Coast Regions, southern Tanzania, in 1999 and 2002. The two IMCI districts, Morogoro Rural and Rufiji, started to implement IMCI in 1997–98, and the two comparison districts, Kilombero and Ulanga, started implementation in 2002. The two comparison districts were chosen for several reasons: they were geographically contiguous though separated from the intervention districts by an uninhabited game reserve, so there is negligible population movement between intervention and comparison areas; they had continuing demographic surveillance; they had similar or lower mortality rates; and they had no immediate plans to implement IMCI. Figure 1 shows the timing of implementation of IMCI and each of the five main study components. We first assessed the quality of case-management for illness in children, availability of drugs and vaccines, and supervision involving case-management, through a cross-sectional survey in a sample of health facilities from all four districts in August, 2000: detailed methods and findings were reported elsewhere (Armstrong Schellenberg et al. 2004). Second, household

surveys were used to assess indicators of children's health in a probability sample of children from all four districts13 in July–August, 1999, early in the implementation phase, and again in July–August, 2002. Third, survival in children in a part of each district was tracked through demographic surveillance (INDEPTH Network 2002) throughout the study, with particular emphasis on a predefined (selected a priori rather than after examining the results) 2-year period from mid 2000, by which time IMCI implementation was thought to have reached sufficiently high coverage for a sufficiently long period for an effect on survival to be measurable. Fourth, information on contextual factors (programmes and issues other than IMCI that might have affected children's health in the four districts during the study period) was gathered through interviews with all health contributors (i.e., groups active in health issues) in the study districts and desk review of plans, budgets, and reports, together with data from the child-health surveys. Fifth, we estimated the economic cost (including the value of donated goods, volunteer staff time, and replacement costs of assets such as buildings) of children's health care in IMCI and comparison districts through interviews and record review at national, district, facility and household levels; detailed methods and findings are reported elsewhere (Adam et al. 2003;Adam et al. 2004).

Study setting

Kilombero, Morogoro Rural, Rufiji, and Ulanga Districts are in southern Tanzania and have a total population of about 1·2 million people, of whom 200 000 are younger than 5 years (http://www.tanzania.go.tz/census; accessed Nov 16, 2003). Rufiji (IMCI) and Kilombero (comparison) are low-lying, and

much of the land is in the fertile flood plain of the Rufiji and Kilombero rivers. Morogoro Rural (IMCI) and Ulanga (comparison) have mountainous areas as well as low-lying plains. There are two main rainy seasons, October–December and February–May. There is a broad mix of ethnic groups, although Swahili, the national language, is widely spoken. Most people are subsistence farmers. Most dwellings have wood-framed mud walls with thatched or corrugated metal roofs. Rural roads are generally unpaved, and transport can be difficult in the rainy seasons. The public-health system has a network of hospitals, health centres, and dispensaries, with 3300 to 7000 people served by each facility. Over 70% of the populations live within 5 km of a health facility. Rates of use of health facilities are high; routine reports by the Health Management Information System suggest 3·0 visits per child under 5 years old per year for curative care in 1999. Malaria, pneumonia, and waterborne diseases such as cholera and diarrhoea are the main health problems of the area as reported through the health services and as perceived by local people. Seasonal food shortages are common, and a famine affected much of the country in early 1999. For Tanzania as a whole, expenditure per person on health was US$11·37 in 1999–2000, including private, out-of pocket expenses (Ministry of Finance 2001). Monthly total household consumption and expenditure per person in 2001 was around US$10, of which around 70% was for food (Tanzania National Bureau of Statistics 2003).

IMCI implementation

Implementation of IMCI in Tanzania has been described elsewhere (Armstrong Schellenberg, Bryce, de Savigny, Lambrechts, Mbuya, Mgalula, & Wilczynska 2004). Briefly, the Tanzanian Ministry of Health began IMCI implementation in 1996, and adapted generic IMCI case-management guidelines to reflect national child-health policies (eg, first-line and second-line treatments for malaria and pneumonia) and local terms for illness symptoms and providers. All materials were translated into Swahili and used as the basis for preparation of national and district-level trainers. The target audience for the 11-day training was all health workers in first-level health facilities who provide case-management to children. Most of these health workers have 2–3 years' training in clinical medicine after primary education; around 25% have public-health training after primary education. Through local-government and health-sector reforms, local councils have increased autonomy and control over their own health budgets and plans, and they have access to a limited amount of donor-supported "basket" funding from the health-sector-wide approach (Cassels 1997), whereby the Ministry of Health and partners (the World Bank, the UN Population Fund, and the governments of Denmark, Ireland, the Netherlands, Switzerland, and Germany) pool resources in a common kitty from which funds are then directly disbursed to districts through special accounts of the council health management teams (CHMT; "council" refers to the local government of both rural districts and urban municipalities). The CHMT of Morogoro Rural and Rufiji Districts decided to adopt IMCI and to give highest priority to its introduction and implementation, on the basis of evidence available to them from a sentinel burden-of disease information tool

and a district-health-budget mapping tool developed by the Tanzania Essential Health Interventions Project (TEHIP) (de Savigny et al. 2004). TEHIP also provided financial resources to districts of about US$0·92 per person per year to simulate sector-wide basket funding (Cassels 1997) 3 years in advance of the actual start of basket funding. The CHMT of Morogoro Rural and Rufiji reported that over 80% of health-workers managing children in first-level facilities had been trained in IMCI by mid 2000 in an 11-day course with about 30% of the training time spent in clinical practice. TEHIP tools were not available in either of the two comparison districts.

Health-facility survey

We selected a representative sample of 75 health facilities from government dispensaries and health centres (Armstrong Schellenberg, Bryce, de Savigny, Lambrechts, Mbuya, Mgalula, & Wilczynska 2004). Within chosen health facilities, the individuals eligible for inclusion in the survey were the first six sick children aged 2–59 months who attended on the day of the survey for an initial visit for any illness and whose mother consented to take part. Through observation of case-management, exit interviews with carers, reexamination, and interviews with health-care providers, we collected information on 29 indicators relating to assessment, classification, and treatment of the child, counselling and communication with the mother, and health-systems support. We could not do a before-IMCI health-facility survey because implementation of IMCI had already started before this study began in 1999.

Household surveys

Detailed information on the 1999 survey is given elsewhere (Armstrong Schellenberg et al. 2003). Briefly, we took a representative cluster sample of about 2300 rural households from the four districts in July–August, 1999. We chose 30 rural clusters each of 20 households from three of the four districts, and 25 rural clusters of 20 households from the fourth district, Kilombero, by use of a modified scheme similar to the Expanded Programme of Immunizations scheme (Bennett et al. 1994) that ensured an equal probability of selection for every household. A modular questionnaire about the health of all children under 5 years was administered to consenting heads of households, generating information on household-level child-health indicators as agreed by an inter-agency working group on IMCI including representatives from WHO, UNICEF, the US Agency for International Development (USAID), the US Centers for Disease Control and Prevention, and the USAID-funded BASICS Project. Information on proxy markers of household socioeconomic status was collected, such as household ownership of a radio, a tin roof, a bicycle, and the education and occupation of the household head. Mothers or carers (we use “mother” to denote the main carer) of all children under 5 years old were interviewed about their educational attainment, whether or not the child was currently breastfed, and if so what other food or drink the child had received during the previous 24 h. Information on routine vaccinations was collected directly from health cards or, if no health card or other written record was available, according to the mothers’ recall. Mothers were asked whether the child had received vitamin A supplementation and, if so, how long ago. Mothers were then asked about any illness each child had during the 2 weeks

before the survey and what action had been taken. For children who had been sick, further modules elicited detailed information about use of appropriate (non-traditional) health-care providers including village health workers, dispensaries, health centres, hospitals, or private doctors. Information was collected on the care the child received from each such provider and any other treatments the child had taken. Special attention was given to the care of children with danger signs: fast or difficult breathing, seizures or convulsions, extreme sleepiness, excessive vomiting, or inability to drink or breastfeed (Armstrong Schellenberg, Bryce, de Savigny, Lambrechts, Mbuya, Mgalula, & Wilczynska 2004). Children were invited to attend a measuring station in the middle of the village, where they were weighed on digital scales (Seca Vogel and Halke GmbH, Hamburg, Germany) and their height (if 2 years or older) or length (under 2 years) was measured with purpose-made instruments. A generic version of the questionnaire is available from the authors on request. In July–August, 2002, we did a similar follow-up survey. Households were selected from the same villages (clusters) as in 1999. Within selected villages, the chance of visiting the same household was small: a single subvillage (*kitongoji*) was chosen randomly and 20 households selected. We took care to ensure that no survey staff visited a village that they had worked in during the earlier survey. The questionnaire was translated to Swahili, back translated, pre-tested, and pilot tested. Quality-control measures in each cluster included supervisors accompanying one to three interviews; households reported to be empty being visited by a supervisor; re-interviewing by a supervisor of a maximum of two mothers bringing their children to be weighed and measured, with information from the two interviews compared

and discrepancies discussed and resolved with the original interviewer; and weight and height measurements being repeated for up to two children. Repeat measurements were done in most of the clusters, but we could not do them in every cluster because the supervisors also had to select clusters for the next day's work. For some areas these were up to 5 h travel away by car, boat, bicycle, or foot, and in other areas the sensitization of the communities and selection of households took many hours, limiting the time available for quality control. Weight-for-age, height-for-age, and weight-for-height *Z* scores were calculated with reference to the standards of the US National Centers for Health Statistics by use of the EPINUT module of EPI-Info version 6.0. Low weight for age, stunting, and wasting were defined respectively as weight-for-age, height-for-age, and weight-for-height *Z* scores of less than –2, with exclusion of outliers (*Z* score of less than –5 or more than 3). Because stunting is most prevalent at ages 24–59 months and wasting at 12–23 months (WHO 1995), analyses were done for these subgroups. Data were processed in FoxPro (version 2.6) and analysed in Stata (version 6), following an analytical plan previously agreed by the investigators. All analyses were adjusted for clustering by use of standard Stata commands such as *svymean* and *svylogit*. Probability values should be interpreted with caution given the nonrandomized study design and the large number of tests. We did significance testing to look for evidence of four types of differences: between IMCI and comparison districts in each of the two surveys; between 1999 and 2002 for all four districts combined; between IMCI and comparison areas with 1999 and 2002 data combined; and for an interaction between IMCI and time—i.e., whether the difference between IMCI and comparison districts

changed on average between 1999 and 2002. The latter effects are potentially attributable to IMCI, provided that there were no contextual factors that explained them.

Demographic surveillance

Because routine registration of births and deaths in Tanzania is rare, we used demographic surveillance systems (DSS) to measure children's survival in a part of each of the four districts. In Kilombero and Ulanga districts, the DSS started in 1996 with a baseline census in a population of 52 000, covering six contiguous villages of Kilombero district (10% of the district population) and 12 contiguous villages of Ulanga (16%). These areas are not a representative sample of either district. Since January, 1997, an interviewer (one of about 40 full-time staff) has visited each household every 4 months and collected information on pregnancies, births, deaths, and migrations, using the household registration system (Binka et al. 1999). Births and deaths are also reported continuously by key informants based in each *kitongoji*. Extensive quality control measures include repeat interviews in a randomly selected 10% of households. Data from each week's work are used to update the household registration system database before a weekly field meeting. Checking programs are run and queries referred back to the field team for correction within 2 weeks of the original interview. In Rufiji district, field procedures, quality control, and data management are similar to those in Kilombero and Ulanga DSS. Rufiji DSS started in 1998 with a baseline census in a population of about 70 000 people covering 32 villages (44% of the district population). In Morogoro Rural district, demographic and mortality surveillance

began in 1992 with an initial census, which has since been repeated annually in about 85 000 people in 50 villages (16% of the district population). Continuous mortality surveillance provides information on numbers and probable causes of death by use of the verbal autopsy method. About 70 villagers act as enumerators for the annual census update and as key informants for reporting deaths, each of which is followed up by one of four clinical officers from the CHMT. Data entry uses a tailor-made FoxPro database system. Data quality is ensured by checks in the field, during and after data entry. Supervisors visited a random sample of households to verify entries on the census forms and to check that all households visited have been included in the census and that no non-existent households have been included. After each census, re-interviews are done for a sample of households for each enumerator.

Analysis of mortality

Our primary focus was to compare mortality over the 2-year period starting in mid 2000, by which point IMCI implementation was thought to have reached sufficient sustained coverage for any effect on children's survival to be measurable, as judged by an independent review panel. Following an agreed analytical plan, we compared mortality rates per 1000 children under 5 years per year between IMCI and comparison areas from mid 2000 to mid 2002, checking for any differences in 1999, which served as a baseline for the mortality analysis. Note that the widely used children's survival measure of 5q0 is about 4·4 times these rates, because the 5q0 is a cumulative probability of survival to age 5 years and not an annual rate. Adjustments for

age (<1 year and 1–4 years) and rainfall (estimated from remote sensing data) were made with Poisson regression models, and the between-district differences compared by *t*-test-based methods of adjusted residuals, as appropriate for clustered data with a small number of clusters (Hayes & Bennett 1999). With only four districts, p values from this approach are likely to be conservative. We also calculated p values from Poisson regression ignoring between-district variation. Secondary analysis made use of all available DSS data to summarise longer-term trends in children's survival in relation to IMCI. We used Poisson regression for the data from each DSS area separately, testing for the size and statistical significance of the trend in mortality rates over time. Owing to difficulties with data completeness, analysis was repeated with and without Morogoro data for the year 2000.

Contextual factors

We summarised factors other than IMCI that might have affected child health in the four districts, with emphasis on those that might have changed over the study period, including geographical, environmental, and demographic features, health-care infrastructure and activities, and other health-related programmes, activities, or events (including disasters and famines). These factors were related to quantifiable indicators from the household surveys. In addition to using data from the household surveys, we contacted around 40 health contributors in the four study districts, including CHMT, TEHIP, non-governmental organisations, religious missions, and bilateral and multilateral aid organisations. Information on delivery of routine health care and other

relevant activities was systematically collated from written reports and interviews with key informants.

Economic costs

Detailed methods are given elsewhere (Adam, Manzi, Kadundwa, Armstrong Schellenberg, Mgalula, de Savigny, Mbuya, & Wilczynska 2003;Adam, Manzi, Armstrong Schellenberg, Mgalula, de Savigny, & Evans 2004). Briefly, cost data were collected for the start-up period of implementing IMCI (1996 to 1997) and for maintaining health services for children under 5 years including IMCI subsequently. Costs were estimated from the societal perspective and were collected from the levels of nation, district, hospital, primary health facility, and household. Among the costs included were those for drugs and vaccines; training costs attributable to care of children under 5 years, including but not restricted to IMCI; the annualised cost of capital items; and the opportunity cost of staff time spent in consultation with children under 5 years (assessed through a time-and motion study) and time spent attending meetings and undertaking supervision visits.

Table 8: Selected indicators showing quality of care and health-system support in IMCI and comparison districts in August, 2000

	IMCI	Comparison	p*
Child checked for presence of cough, diarrhoea, and fever	219/231 (95%)	67/188 (36%)	<0.0001
Child correctly classified	139/219 (63%)	66/176 (38%)	<0.0001
Child needing oral antibiotic or oral antimalaria given correct prescription	159/219 (73%)	63/178 (35%)	<0.0001
Carer of child prescribed an oral medication reports correctly at facility exit how to give the treatment	163/225 (72%)	100/179 (56%)	0.02
Mean index of availability of essential oral treatments	0.93 (n=39)	0.95 (n=35)	0.47
Health facility received at leas tone supervisory visit that included observation of case management during the previous 6 months	19/37 (51%)	7/34 (21%)	0.007

F-tests comparing area with and without IMCI unless otherwise stated. ORS, oral antibiotic, oral antimalarial, or a combination of these medications

Household costs included travel and out-of-pocket expenditures to obtain care for children under 5 years but did not include a monetary value of time lost in seeking care. Costs at all these levels were summed to obtain the total cost to the district of providing care for children under 5 years. To allow comparison across districts, cost estimates were standardised to a district with a population of 50 000 children under 5 years. Estimates of the additional cost to the district of implementing IMCI were based on the difference in cost of care for children under 5 years between the standardised IMCI and comparison districts.

Role of the funding sources

The funding sources were not involved in the study design; collection, analysis, or interpretation of data; writing of the paper; or the decision to

submit the paper for publication. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

8.4 Results

Quality of care

The introduction of facility-based IMCI was associated with improved quality of care as measured through the health-facility survey in August, 2000, after the end of the IMCI phase-in (figure 1). More than twice as many children were checked for cough, diarrhoea, and fever in the IMCI facilities as in the comparison districts (p<0·0001; table 1).12 Sick children were 1·7 times more likely to be correctly classified in IMCI districts than in comparison districts (p<0·0001). Drug availability was reasonably good and similar in IMCI and comparison areas at the time of the survey (p=0·47; table 1). However, the proportion of sick children needing oral antibiotics, oral antimalarials, or both who were prescribed them correctly was two times higher in the IMCI districts than in comparison districts (p<0·0001). Of carers whose children had been prescribed oral rehydration solution (ORS), oral antibiotics, or oral antimalarials, a higher proportion in the IMCI districts than in comparison districts reported correctly at the facility exit how to give the treatment (rate ratio 1·3, p=0·02). Supervisory visits that included observation of case-management were more common in IMCI districts than in comparison districts (p=0·007). Follow-up visits after IMCI training were not included in these

calculations. Overall, IMCI facilities were significantly better than, or similar to, comparison facilities for all but one indicator out of a total of 29.

INDICATOR	YEAR	DISTRICT				P-values			
		Morogoro Rural [IMCI] (number of observations)	Rufiji [IMCI] (number of observations)	Ulanga [No IMCI] (number of observations)	Kilombero [No IMCI] (number of observations)	IMCI vs comp-arison areas	Change over time 1999 to 2002	Difference between IMCI and comparison	Difference between IMCI and comparison changed over time
UTILISATION & CARE									
Appropriate care-seeking	1999	36% (239)	46% (273)	38% (273)	47% (229)	0.81	0.02	0.45	0.36
	2002	32% (229)	45% (302)	35% (276)	31% (151)	0.17			
Care-seeking rate for children with danger signs	1999	51% (78)	55% (84)	62% (74)	74% (73)	0.02	0.05	0.54	0.006
	2002	48% (64)	60% (78)	46% (71)	38% (42)	0.15			
Proportion of children admitted in last year*	1999	7% (450)	5% (545)	12% (570)	17% (406)	0.002	0.45	0.002	0.002
	2002	9% (503)	6% (547)	11% (504)	13% (360)	0.06			
ORS use among children with diarrhoea	1999	13% (45)	38% (40)	15% (48)	6% (47)	0.03	0.31	0.08	0.07
	2002	14% (42)	41% (54)	27% (55)	8% (26)	0.01			
HOME MANAGEMENT OF DISEASE									
Sick child (today) receives increased fluids and continued feeding	1999	1% (136)	5% (125)	9% (140)	6% (107)	0.02	0.31	0.23	0.05
	2002	8% (133)	5% (117)	8% (149)	4% (76)	0.89			
CARETAKER KNOWLEDGE									
Caretaker knows at least two signs for seeking care immediately	1999	24% (316)	19% (357)	21% (385)	26% (286)	0.54	<0.0001	0.11	0.93
	2002	33% (384)	27% (400)	32% (379)	38% (284)	0.16			
FEEDING & NUTRITION									

Low weight for age	1999	29% (429)	32% (518)	28% (559)	23% (344)	0.10	<0.0001	0.03	0.45
	2002	23% (483)	24% (518)	22% (494)	16% (331)	0.07			
Stunting prevalence in children aged 24-59 months	1999	61% (233)	59% (264)	54% (303)	46% (180)	0.04	<0.0001	0.07	0.07
	2002	42% (289)	44% (296)	45% (282)	32% (195	0.45			
Wasting prevalence in children aged 12-23 months	1999	17% (72)	9% (95	9% (115)	13% (85)	0.52	0.02	0.43	0.79
	2002	5% (91)	8% (100	6% (110)	4% (67)	0.66			
Child under 4 months of age is exclusively breastfed	1999	25% (52)	17% (59)	26% (42)	26% (27)	0.46	<0.0001	0.69	0.89
	2002	23% (30)	22% (36)	30% (30)	35% (23)	0.34			
Child aged 6-9m receives breastmilk & complementary feeding	1999	83% (30)	94% (49	98% (41	94% (32	0.17	0.008	0.23	0.26
	2002	97% (38)	100% (43	97% (39)	100% (36)	0.96			
Mean meal frequency for breastfed 1-year-olds	1999	2.6 (67)	2.8 (87	2.8 (98)	3.2 (82)	0.05	0.01	0.06	0.03
	2002	2.9 (81)	3.3 (98	3.1 (99)	3.2 (57)	0.61			

Table 9: Indicators of feeding, nutrition, carers' knowledge, home management of disease, use of health services, and care in 1992 and 2002

Household surveys 1999 and 2002

In 1999, data were available from 2006 children under 5 years of age living in 1321 households with children of this age-group in the 120 rural clusters, representing 93% of eligible households: residents of 137 (6%) were away and 21 (1·0%) refused to take part.13 In the 2002 survey, 1932 children were identified living in 1341 households with children of this age-group within the same villages, representing 94% of eligible households: residents of 142 (6%) were away and nine (0·4%) households refused to take part. The age profile of children involved in the two surveys was similar, with 24% and 21% of children being younger than 1 year in 1999 and 2002, respectively.

Around half of all children were reported by their carers as having been ill in the 2 weeks before the surveys (1026/1968 [52%], data missing for 38 children in 1999; and 965/1914 [50%], data missing for 18 children in 2002). 42% of carers sought care from an appropriate health-care provider in 1999 compared with 36% in 2002 (p=0·02; table 2). There was no evidence of any difference in care-seeking between IMCI and comparison districts (p=0·45) or of a differential change in care-seeking between IMCI and comparison districts over time (p=0·36). Care-seeking was generally more common for children reported as having had danger signs: in 1999, 86 (53%) of 162 such children in IMCI districts and 100 (68%) of 147 in comparison districts had reportedly been taken to an appropriate provider. In the 2002 survey, the rate of care-seeking for children with danger signs had risen slightly in the IMCI districts (78/142 [55%]) and had fallen in comparison districts (49/113 [43%]; p=0·006 for the differential change overtime). Over 10% (200/1971) of children had been admitted to a health facility in the year before the 1999 survey, with admission being more common in the comparison districts than in the IMCI districts (p=0·002;

table 2). Although the difference persisted in the 2002 survey, it was much less striking because the rate of hospital admissions had risen by 1% on average in the IMCI districts and fallen by 3% in the comparison districts (p=0·002 for the differential change between IMCI and comparison areas).

Among children sick with diarrhoea in the 2 weeks before the survey, the rate of use of ORS showed large variations between the districts, from 6% to 38%. Nevertheless, use of ORS was more common on average in IMCI than in comparison areas in both surveys (p=0·03 in 1999 and p=0·01 in 2002). The rate of appropriate home management of disease, measured partly by the proportion of children sick on the day of the survey who had received increased fluids and continued feeding, was under 10% in all districts and both surveys. Nevertheless, there was evidence of differential improvement between the IMCI and comparison districts (p=0·05), with the proportion in IMCI districts increasing by 4% on average between 1999 and 2002 and that in comparison districts decreasing by 1%.

In 1999, more than a fifth of carers knew at least two signs for seeking care immediately, and the proportion with such knowledge increased in all districts by 2002 to around a third (p<0·0001 for the average change over time). There was no evidence of a differential change in such knowledge between IMCI and comparison districts (p=0·93).

Anthropometric indicators of nutritional status were available for 1852 (92%) of 2006 children in the 1999 survey and 1826 (95%) of 1932 children in the 2002 survey. Outliers (extreme *Z* scores) were omitted for 100 (5%) children in 1999 and for 57 (3%) in 2002. Low weight for age is common in the study area, with 29% (528/1852)

of all children affected in 1999. The prevalence of low weight for age had decreased in all districts by 2002, to 22% (395/1826; p<0·0001). Low weight for age affected 4–5% more children in the IMCI districts than in the comparison districts in both years (p=0·03). Wasting was found in 11% of children aged 12–23 months in 1999 (42/367), a few months after a famine, and the rate had fallen to 6% (23/368) in 2002 (p=0·02), with no evidence of differences between IMCI and comparison areas (p=0·43) or a differential change over time (p=0·79). Stunting affected 60% (297/497) of children aged 24–59 months in IMCI districts in 1999, about 10% more than in comparison areas (51%;247/483; p=0·04). By 2002, however, children in IMCI areas had "caught up", and rates of stunting were similar in IMCI and comparison areas (249/585 [43%] *vs* 191/477 [40%]; p=0·07 for the differential change over time). When expressed as a mean height-for-age *Z* score in children aged 24–59 months, the differential change between IMCI and comparison districts reached conventional statistical significance, although we emphasise that all p values should be interpreted with caution (p=0·05, data not shown).

Exclusive breastfeeding in children under 4 months of age was practised by 23% (41/180) of mothers in 1999 and 27% (32/119) by 2002 (p<0·0001). For children aged 6–9 months, 93% (141/152) were receiving breast milk and complementary feeding in 1999 and 99% (154/156) in 2002 (p=0·008). Neither of these breastfeeding indicators showed evidence of a difference between IMCI and comparison districts (p=0·69, p=0·23), nor of a differential change over time (p=0·89, p=0·26). In 1999, breastfed 1-year-old children received an average of 2·7 meals per day in IMCI districts and 3·0 in comparison areas (p=0·05). By 2002, these differences were no longer evident (p=0·03 for the differential change over time).

Table 10: Mortality rates from July, 1999 to, June 2002

	Deaths	Child- years	Death rate per 1000 child-year
July,1999, to June 2000			
Morogoro	252	11,303	22.3
Rufiji	387	12,212	31.7
Total IMCI districts	639	23,516	27.2
Kilombero	146	4,687	31.1
Ulanga	96	4,289	22.4
Total comparison districts	242	8,977	27.0
July,2000, to June 2002			
Morogoro	522	23,985	21.8
Rufiji	698	25,979	26.9
Total IMCI districts	1,220	49,964	24.4
Kilombero	362	12,685	28.5
Ulanga	257	9,280	27.7
Total comparison districts	619	21,965	28.2

Survival

Mortality rates in children younger than 5 years, from the area of each district under demographic surveillance, are shown in table 3. In the period from July, 1999, to June, 2000, during the phase-in of IMCI, mortality in children younger than 5 years was 27·2 per 1000 child years in IMCI districts and 27·0 per 1000 child-years in comparison districts, giving a rate ratio of 1·01 and a rate difference of 0·2 deaths per 1000 child-years. Note that these rates are equivalent to a 5q0 of around 0·12 (120 per 1000 live births). Over the next 2 years, from July, 2000, to June, 2002, mortality rates were 13% lower in the IMCI districts than in the comparison districts (rate ratio 0·87), corresponding to a rate difference of 3·8 fewer deaths per 1000

child-years. Adjustment for the difference between the areas in 1999 gives a rate ratio of 0·86, almost identical to the unadjusted value. Adjustments for age (<1 year and 1–4 years) and estimated rainfall were made with Poisson regression models but had no effect on the estimated rate ratio (data not shown). With allowance for variation between districts and use of a normal approximation based on the log rate ratio, the 95% CI was –7 to 30 (p=0·28 by *t* test). If we ignore between-district variation, the 95% CI for the 13% reduction in mortality associated with IMCI was 5 to 21 (p=0·004 from likelihood-ratio _2 test).

Additional mortality data were available from some of the DSS sites from January, 1997, until December, 2002 (figure 1). We used all available data from complete years to assess trends over time in each district. This analysis found no evidence of a change over time in mortality among children under 5 years old in one of the two comparison districts, Kilombero, over the 6 years; there was an estimated 2% annual increase in mortality rate (95% CI –2 to 6; p=0·23). In the second comparison district, Ulanga, there was an annual decrease in mortality of 6% (2 to 10; p=0·002; figure 2). In districts with IMCI, mortality data were less complete, but analysis of all available data for whole calendar years showed an annual decrease of 11% in mortality in Rufiji district between February, 1999, and December, 2002 (95% CI 7 to 16; p<0·0001) and an annual decrease of 14% from January, 1997, to December, 2001, in Morogoro Rural district (95% CI 11 to 17; p<0·0001). Owing to data incompleteness, the Morogoro Rural analysis was repeated without data from the year 2000; the annual decrease in mortality in children under 5 years was 11% (8 to 15; p<0·0001).

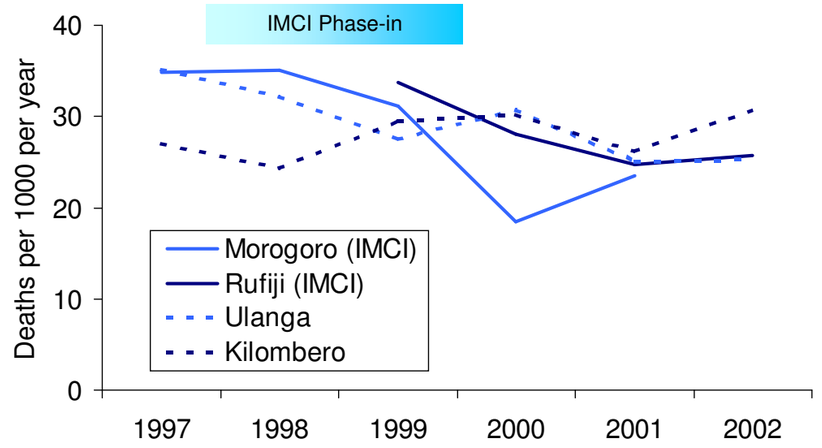

Figure 3: All-cause mortality in children under 5 year of age, 1997-2002

Contextual factors

The desk reviews of plans, budgets, reports, and expenditure and interviews with health contributors suggested several factors other than IMCI relevant to child health that differed between IMCI and comparison districts. We were especially concerned to identify those factors that might account for the observed differential changes in survival between IMCI and comparison districts—ie, factors that changed rapidly and differentially during the study period. The factors identified were limited to malaria-control efforts, vaccination programmes, and coverage of vitamin A supplementation. Of children who had fever in the 2 weeks before the 1999 household survey, 42% had been given an antimalarial drug (table 4). In 2002, only 28% of such children had received an antimalarial drug ($p<0·0001$), with no evidence of differential change in IMCI and comparison districts ($p=0·35$). In 1999, most of these children (85%) received chloroquine, whereas in 2002, the most commonly used drugs were

sulfadoxinepyrimethamine (53%), quinine (24%), and amodiaquine (17%). A second malaria-control effort that differed between the districts was social marketing of treated mosquito nets, and we were also concerned that coverage of untreated nets purchased through the private sector might have changed differentially. Use of untreated nets the night before the 1999 household survey varied widely between districts, from 14% in Morogoro Rural district (IMCI) to 59% in Kilombero district (without IMCI). Use of nets increased strikingly in all four districts by 2002, reaching 85% in Kilombero and 35% in Morogoro Rural. Although the increase in use was larger in IMCI districts than in comparison districts when measured as a ratio of 2002/1999 rates (1·95 *vs* 1·57; p=0·03), use remained significantly higher in comparison districts than in IMCI districts in 2002 (66% on average in comparison districts and 41% in IMCI districts; p<0·0001). Use of nets that had been treated in the 6 months before the survey was rare in all districts in 1999, at less than 7%, and increased in all districts by 2002, by 4–14%, with no evidence of a differential change between IMCI and comparison areas over time (p=0·14). Although vaccine coverage was generally high (over 80%) in all districts and during both surveys, there was evidence of a small decrease in coverage of BCG vaccine between the two surveys, from 97% to 96% (p=0·02). We also found a differential decline in coverage of DPT vaccine from the 1999 value of 86%. In 2002, DPT coverage increased to 95% in the comparison districts but had fallen to 82% in the IMCI districts (p=0·03 for the differential change over time). Coverage of vitamin A supplementation was only 14% in 1999 and similar in IMCI and comparison areas. In 2002, coverage had increased greatly in all districts, to an average of 76% (p<0·0001), with no apparent difference between the districts (p=0·73) nor any evidence of a differential change over time (p=0·98). For vaccination coverage and malaria-control efforts, the higher coverage in comparison districts would have tended to negate any apparent effect of IMCI on

child survival. For vitamin A supplementation, the coverage was similarly low in all four districts in 1999, rose equally by 2002, and cannot therefore account for the greater drop in mortality in the IMCI areas over the study period.

Table 11: Indicators reflecting programmes and issues other than IMCI that could have affected child health and survival during the study period

INDICATOR	YEAR	DISTRICT				P-values			
		Morogoro Rural (IMCI)	Rufiji (IMCI)	Ulanga (comparison)	Kilombero (comparison)	IMCI vs comp-arison areas	Change over time 1999 to 2002	Difference between IMCI and comparis on	Difference between IMCI and compariso n changed over time
Child with fever receives antimalarial drug	1999	67/174 (39%)	80/199 (40%)	58/180 (32%)	95/164 (58%)	0.23	<0.0001	0.33	0.35
	2002	54/177 (31%)	54/217 (25%)	43/177 (24%)	37/107 (35%)	0.86			
Child sleeps under net	1999	64/449 (14%)	146/543 (27%)	174/565 (31%)	236/399 (59%)	<0.0002	<0.0001	<0.0001	0.03
	2002	175/500 (35%)	254/547 (46%)	268/504 (53%)	299/352 (85%)	<0.0001			
Child sleeps under treated net*	1999	13/449 (3%)	19/543 (3%)	28/567 (5%)	26/399 (7%)	0.10	<0.0001	0.22	0.14
	2002	41/500 (8%)	87/547 (16%)	44/504 (9%)	74/352 (21%)	0.54			
Anemia in children >=6m (Hb<11.0 g/dL)	1999	322/368 (87%)	408/440 (93%)	435/499 (87%)	293/333 (88%)	0.23	<0.0001	0.07	0.67
	2002	353/434 (81%)	409/477 (86%)	478/452 (84%)	214/309 (69%)	0.06			
BCG vaccine coverage (informed or registered)	1999	80/81 (99%)	94/100 (94%)	112/115 (95%)	98/99 (99%)	0.97	0.02	0.94	0.97
	2002	91/96 (95%)	104/108 (96%)	108/114 (95%)	69/71 (97%)	0.97			
DPT vaccine coverage (informed or	1999	67/80 (84%)	90/100 (90%)	95/118 (81%)	90/99 (91%)	0.68	0.40	0.15	0.03

registered)	2002	72/96 (75%)	95/108 (88%)	108/114 (95%)	68/71 (96%)	0.001			
Polio vaccine coverage (informed or registered)	1999	65/80 (81%)	86/100 (86%)	94/118 (80%)	87/99 (88%)	0.90	0.21	0.11	0.12
	2002	57/93 (61%)	92/108 (85%)	97/114 (85%)	65/71 (92%)	0.007			
Measles vaccine coverage (informed or registered)	1999	70/80 (88%)	89/100 (89%)	99/118 (84%)	95/99 (96%)	0.83	0.51	0.33	0.72
	2002	84/96 (88%)	96/108 (89%)	105/114 (92%)	67/71 (94%)	0.14			
Vitamin A supplementation coverage	1999	12/95 (13%)	13/99 (13%)	14/111 (13%)	14/97 (14%)	0.71	<0.0001	0.73	0.98
	2002	73/95 (77%)	81/114 (75%)	89/114 (78%)	53/71 (75%)	0.84			

Economic costs of under-five care

IMCI was not associated with higher economic costs than conventional care (care without IMCI). In fact, the reverse was found: the cost of care per child younger than 5 years was estimated at US$11·19 in IMCI districts and US$16·09 in comparison districts (table 5).15,16 The major components of cost were at district, hospital, primary facility, and household levels, with the estimate of hospital-level costs in the comparison districts accounting for almost half of total cost of care per child (46%). Since we would not have expected IMCI to have affected hospital-level costs to such an extent, and because access to hospitals was better in comparison than in IMCI districts, we recalculated the cost of care per child younger than 5 years without the hospital component and found similar total costs per child in IMCI and comparison areas (US$8·30 in the IMCI districts, US$8·76 in the comparison areas).

Table 12: Annualised cost of care per child younger than 5 years, standardised districts of 50,000 children younger than 5 years with and without IMCI

	Cost in standardized districts with IMCI		% of total cost	Cost in standardised comparison district		% of total cost
	TZS	(US$)		TZS	(US$)	
Level						
National	129	(0.17)	1	55	(0.07)	0
District	1,784	(2.30)	21	2,605	(3.35)	21
Hospital	2,243	(2.89)	26	5,692	(7.33)	46
Primary-facility	2,455	(3.16)	28	2,283	(2.94)	18
Household	2,083	(2.68)	24	1,867	(2.40)	15
Total	8,695	(11.19)	-	12,503	(16.09)	-
Total excluding hospital costs	6,452	(8.30)	-	6,810	(8.76)	-

TZS =Tanzania shillings. Data from 1999

8.5 Discussion

Our effectiveness evaluation to estimate the impact of a programme that was selected and implemented by district health staff in rural Tanzania showed evidence that case-management was improved, the mortality rate in children younger than 5 years was 13% lower in districts with IMCI than in comparison areas, and that costs of children's health care with IMCI were similar to or lower than those with conventional case-management, suggesting that facility-based IMCI is highly cost effective. Our findings on mortality rates and trends in the presence of facility-based IMCI, although not supporting the same type of inference as a randomized controlled trial covering a large number of districts, support going to scale in Tanzania with this intervention in the context of health-sector reform, basket funding, good facility access, and high utilization of health facilities.

Several design issues must be borne in mind in interpretation of our findings. We set out to evaluate the effectiveness of an integrated delivery strategy encompassing several interventions, such as antibiotics, antimalarials, and oral rehydration therapy, for which efficacy is already well documented (Bryce, Victora, Habicht, Vaughan, & Black 2004). Our objective was to estimate the impact of a programme that was managed by district health staff under routine circumstances, similar to a phase IV study of a drug or vaccine. Our study did not start until 1999, by which time IMCI implementation had started; thus we could not do a before-IMCI health-facility survey. However, we were reassured that before the study started children's survival in the IMCI districts was similar to or worse than that in the comparison districts. A randomised design would not have been possible because implementation of IMCI had already started in two of the four districts that had demographic surveillance

systems. Therefore, we placed much emphasis on documenting and assessing the effect of contextual factors that might confound the observed results. We are reassured that the observed distribution of contextual factors would tend, if anything, to lead to an underestimate of the true impact of IMCI, but in a non-randomised design with a small number of units of analysis we cannot rule out their influence completely.

The study was designed to detect a 20% reduction in mortality, which seemed feasible given that IMCI includes several life-saving interventions, and that baseline mortality rates were high. We found a smaller effect than we had expected, and the 95% CI for this estimate included the value of zero, corresponding to no effect. Nevertheless, in many large-scale public-health evaluations the number of available units of analysis is small, and even if the result had been statistically significant it would be hard to interpret in strict probabilistic terms. For this reason, we tried hard to document intermediate changes that could be ascribed to IMCI implementation and also contribute to reducing mortality, thus strengthening the plausibility (Victora, Habicht, & Bryce 2004) of an effect on mortality. For example, health-worker performance, including prescription of life-saving drugs, improved substantially; key indicators that could be ascribed to IMCI implementation (such as home management of disease and some care-seeking and feeding practices) showed improvements, although most were still well below what would be desirable; and mean height for age, a good indicator of overall health of children that could be a result of improved disease management and feeding practices (WHO 1995), was significantly improved. Taken together, these results support the hypothesis that IMCI implementation led to a mortality reduction.

We identified several areas within facility-based IMCI that deserve careful attention, with a view to the rethinking of parts of this strategy. Results from Uganda suggest that supportive supervision is associated with improved quality of care (unpublished). We found that although general visits from supervisory teams were frequent, many such visits did not involve case management. Supportive supervision involving case management observation was more common in the districts with IMCI than in comparison areas, yet there was still room for improvement, with a fifth of such staff not having had such a visit in the previous 6 months. Despite many attempts to develop an "IMCI supervision checklist", implementation has proved impossible owing to the many duties that supervisors are expected to do. An integrated approach might help and is under consideration in Tanzania. We also found that less than a fifth of children needing referral were actually referred (17%; 95% CI 0 to 41; n=12) (Armstrong Schellenberg, Bryce, de Savigny, Lambrechts, Mbuya, Mgalula, & Wilczynska 2004), despite an expectation that IMCI guidelines would lead to a massive increase in referrals (Font et al. 2002). More than 60% of first-level health facilities are over 2 h travel time from their closest referral facility (data not shown), and a lack of transport and money together with the need to care for other children often means that mothers are unable to travel such distances with a sick child (unpublished and Hausmann and colleagues (Muela, Mushi, & Ribera 2000)). Health workers are part of the communities they serve, and a possible explanation is that they do not refer children who are unlikely to be taken to a referral facility. The IMCI guideline on "Where referral is not possible", which is part of the IMCI training course in Tanzania, goes some way towards supporting health workers to offer these children the best possible treatment.

The potential impact of IMCI is likely to depend largely on the efficacy and availability of appropriate treatment for malaria, which is the main cause of morbidity and mortality in the study area. Nationally, the first-line antimalarial drug changed in 2000 from chloroquine to sulfadoxine-pyrimethamine, owing to widespread drug resistance. There were initially problems with quality control and delivery, which might have led to the decrease in treatment of fever with antimalarials, from 42% to 28% in children sick in the 2 weeks before each survey. Despite increased efficacy, the newly introduced sulfadoxine-pyrimethamine was apparently neither so widely available nor as popular as chloroquine had been in 1999 and this is likely to have reduced the potential effectiveness of IMCI in the timeframe of this study.

From its origins as a case-management strategy, IMCI later developed into three linked components: case management, health-facility support, and household and community support. The third component, often known as “community IMCI”, consists of health education messages and programmes in support of 17 key family practices, focused around growth promotion and development, disease prevention, care-seeking, and compliance with health-workers’ advice. This package has not been implemented in our study area. Nevertheless, many of the activities with high coverage in all four districts are compatible with community IMCI, including the use of treated mosquito nets and vitamin A. Tanzania has a long history of community based activities and programmes: for example, all villages in Morogoro Region had two village health workers trained in the 1980s, and in a few villages these people remain active in health promotion, including growth monitoring of children, supplemental feeding of those identified to be at risk, and village health days to promote vaccination. The potential gains from such outreach are clear, but there is

currently no mechanism by which such community-based health workers can be motivated, supervised, and supported on a large scale. Given the difficulties in providing support and supervision to peripheral-facility-based health workers, how a much larger force of unsalaried lower-level workers could be managed and sustained remains unclear.

The finding that economic costs of IMCI were similar to or less than those of conventional children's health care was unexpected. The explanation is that substantial amounts of money were spent on care for children in comparison districts, and that this roughly equaled the cost of IMCI. There is no evidence that these districts are atypical of rural Tanzania: as is often the case, there was continuing donor investment in health programmes including from multilateral agencies such as UNICEF, from bilateral agencies such as the Swiss Agency for Development and Cooperation, and from nongovernmental organisations such as Plan International. Estimated funding for health from major donors such as the Swiss Agency for Development and Cooperation and Development Cooperation Ireland was around US$0·80 per person in the comparison districts, not very different from the TEHIP funding of US$0·92 per head. Furthermore, IMCI was implemented at a financial cost within the basket funding available to all districts through health-sector reform. For example, the cost of training 48 health workers would use between 1% and 6% of current basket funding allocated to each district. Implementation in the comparison districts started in 2002.

More than 10 years ago, an early estimate of the likely cost-effectiveness of IMCI reported that "implementation of the integrated cluster of treatments, including

hospital services, would cost between $30 and $100 per DALY saved"(World Bank 1993). Furthermore, there was an expectation that, if health services were well used, child mortality rates might be reduced by 50–70%. With the benefit of hindsight, these expectations were somewhat optimistic. Implementation of IMCI has proved to be far more challenging than was first thought: although virtually every country in Africa has started to implement the strategy (WHO 2004), not one country yet has high enough national level coverage to achieve a measurable effect on mortality. This lack of high-level coverage, and an intervention perceived to be very expensive by many donors, might have led to a general feeling among international policy-makers that IMCI has no effect on children's survival. Our data suggest that high coverage of facility-based IMCI leads to lower child mortality and that the reduction is achievable within existing health budgets. In our setting, simple, practical planning and management tools, developed by TEHIP, for strengthening the capacity of district health systems were the essential first step to achieving this impact.

Contributors

All authors contributed to interpretation of the data and writing of the report. In addition, Joanna Armstrong Schellenberg and Taghreed Adam took part in conception, design, data collection, data management, and analysis; Hassan Mshinda and Don de Savigny in conception and design; Honorati Masanja, Gregory Kabadi, Oscar Mukasa, Sosthenes Charles, Rose Nathan, Katarzyna Wilczynska, Robert Mswia, and Fatuma Manzi in data collection, data management, and analysis; Theopista John in analysis; Leslie Mgalula and Conrad Mbuya in

conception, design, and data collection; David Schellenberg in conception, design, and data management; and Cesar Victora in conception, design, and analysis.

Conflict of interest statement

CV works as a part-time consultant for WHO, one of the institutions involved in implementing IMCI worldwide. The other authors declare no conflicts of interest.

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CHAPTER 9: Impact of Integrated Management of Childhood Illness on inequalities in child health in rural Tanzania

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9.1 Summary

We examined the impact of the Integrated Management of Childhood Illnesses (IMCI) strategy on the equality of health outcomes and access across socio-economic gradients in rural Tanzania, by comparing changes in inequities between 1999 and 2002 in two districts with IMCI (Morogoro Rural and Rufiji) and two without (Kilombero and Ulanga).

Equity differentials for six child health indicators (under weight, stunting, measles immunization, access to treated and untreated nets, treatment of fever with antimalarial) improved significantly in IMCI districts ($p<0.05$) compared to comparison districts, while four indicators (wasting, DPT coverage, care takers' knowledge of danger signs and appropriate care seeking) improved significantly in comparison districts ($p<0.05$) compared to IMCI districts. The largest improvements were observed for stunting among children between 24-59 months of age. The concentration index improved from -0.102 in 1999 to -0.032 in 2002 for IMCI while it remained almost unchanged -0.122 to -0.133 in comparison districts. IMCI was associated with improved equity for measles vaccine coverage, whereas the opposite was observed for DPT antigens.

This study has shown how equity assessments can be incorporated in impact evaluation at relatively little additional cost, and how this may point to specific interventions that need to be reinforced. The introduction of IMCI led to improvements in child health that did not occur at the expense of equity.

9.2 Introduction

Very few studies have assessed trends in socio-economic inequities in health, particularly in low and middle-income countries (Victora et al. 2000). Of these, most studies have addressed cross-sectional status of inequalities in child health and access to interventions (Gwatkin et al. 2000). Earlier publications in Tanzania described inequities in child nutritional status, health care seeking and utilization (Armstrong Schellenberg et al. 2003;Mwageni et al. 2004)

This study is part of the Multi-Country Evaluation of the Integrated Management of Childhood Illnesses (IMCI) strategy. IMCI combines prevention and treatment of common childhood illnesses into simple guidelines and messages for use in first-level health facilities and communities. Primary care alone may not be sufficient for improving health equity (Bishai et al. 2005). Policies that emphasize a primary health care strategy can potentially worsen health inequalities temporarily mainly because new public health interventions and programmes tend to reach those in higher socio-economic status first and later those in lower socioeconomic status (Victora, Vaughan, Barros, Silva, & Tomasi 2000). In addition to assessing the overall impact of IMCI (Armstrong Schellenberg et al. 2004a), the Multi-Country Evaluation also aimed to assess the impact of IMCI on health equity.

In this paper we examine the impact of the IMCI strategy on the equality of health outcomes and access across the socio-economic gradient in rural Tanzania, by comparing changes in inequities between 1999 and 2002 in two districts with IMCI (Morogoro Rural and Rufiji) and two comparison districts (Kilombero and Ulanga).

9.3 Methods

A population-based survey was carried out between July and August 1999 in rural areas of four districts (Kilombero, Ulanga, Rufiji and Morogoro) in South East Tanzania. The study area has been described in detail elsewhere (Armstrong Schellenberg, Victora, Mushi, de Savigny, Schellenberg, Mshinda, & Bryce 2003;INDEPTH Network 2002). The districts are located at 6-8° south, 36-39° east and had a total population in 2002 of approximately 1.2 million people (http://www.tanzania.go.tz/census). The details of the design of the study are described elsewhere (Armstrong Schellenberg, Adam, Mshinda, Masanja, Kabadi, Mukasa, John, Charles, Nathan, Wilczynska, Mgalula, Mbuya, Mswia, Manzi, de Savigny, Schellenberg, & Victora 2004a). Briefly, a probability cluster sample of approximately 2,300 households was selected from the four districts. Thirty rural clusters, each of 20 households, were chosen from three of the four districts and 25 clusters were chosen from Kilombero District. Villages were selected with probability proportional to estimated population size, and one kitongoji (sub-village, with approximately 100 households) was chosen at random from each selected village. Twenty households were chosen from each kitongoji using a modified EPI-type sampling scheme (Bennett et al. 1991) that ensured an equal probability of selection for every household in the sub-village. 10 additional peri-urban clusters in Ifakara town (in Kilombero District) have been omitted from the analysis described here so that all results refer to rural areas. Fieldwork was carried in July and August 1999, and a second survey using exactly the same methodology was carried out in July-August 2002. Households were selected from the same villages (clusters) as in 1999. The chance of visiting the same household was small: in each village, a single sub-village (kitongoji) was randomly chosen and 20 households included. No survey

staff visited a village that they had worked in during the 1999 survey. Quality control measures are reported elsewhere (Armstrong Schellenberg, Adam, Mshinda, Masanja, Kabadi, Mukasa, John, Charles, Nathan, Wilczynska, Mgalula, Mbuya, Mswia, Manzi, de Savigny, Schellenberg, & Victora 2004a).

A modular questionnaire about the health of all children under five years of age was administered to consenting heads of households. We obtained information for proxy markers of household socioeconomic status such as household ownership of assets, housing characteristics, education, and occupation of the household head, household head and mother or caretakers source of income. Caretakers of all children under five years of age were asked about their level of education and any reported child illness during the two weeks before the survey, including action taken. We also collected indicators for morbidity (two week period prevalence of history of fever), nutritional measurements (weight and length or height), coverage of interventions (DPT, measles and polio vaccines both registered and informed, children sleeping under nets treated with insecticide in the last 6 months, and children sleeping under any net), care taker knowledge of care seeking (knowledge of at least two child health danger signs and knowledge of feeding during illness) and home management of illness (children with fever receiving appropriate treatment). Additional information on indicators is available elsewhere (www.who.int/imci-mce).

Children were weighed on digital scales (Seca Vogel & Halke GmbH & Co, Hamburg, Germany) and their height (≥2 years) or length (<2 years old) was measured using locally-made instruments. For convenience, both length and height

will be referred to as height. Weight for age and weight for height Z-scores were calculated with reference to the US National Centers for Health Statistics (NCHS) standards using the EPINUT module of EPI-Info v6.0 (CDC Atlanta, Georgia, US). Underweight, stunting and wasting were defined respectively as weight-for-age, height-for-age and weight-for-height z-scores of less than –2, excluding outliers (z-score of <-5 or >3). Because stunting is most prevalent at ages 24-59 months, and wasting at 12-23 months, analyses were carried out for these subgroups (WHO 1995).

Data sets from the 1999 and 2002 surveys were double entered and checked for consistency in Foxpro for Windows. They were then transferred to STATA 8.0 for statistical analysis. Variables from the two data sets were individually coded, recoded and labeled appropriately. All analyses took into account the clustered nature of the data by employing svy procedures in Stata.

We created an index of household wealth for each survey based on household characteristics, ownership of assets, household head and maternal income, and educational level of the head. Household level characteristics included ownership of the house and type of roofing. Household assets comprised ownership of radio, bicycle, nets, animals such as cows, goats, sheep, donkeys, and chicken and ducks. Household head and maternal income variables included whether they had income from any activities apart from farming such as masonry, petty business, fishing, driving or employment in other formal sectors. The numbers of years of schooling for both the head and mother or caretaker were categorized as none, one to seven for primary and eight or more for secondary education and above. The household

wealth index was the weighted sum of household characteristics, different consumer durables owned by the household, income and number of years of schooling. The weights for the assets in the index were generated by Principal Components Analysis (PCA) on the correlation matrix (Filmer & Pritchett 2001). In each survey, households were categorized into one of five equal sized groups from the most poor to the least poor.

To assess whether the implementation of IMCI had reduced inequalities, we calculated concentration indices (Kakwani, Wagstaff, & Doorslaer 1997;Wagstaff, Paci, & van Doorslaer 1991) for a selected list of key coverage interventions and nutritional status and present all indicators as positive measures. The outcomes included anthropometric measures (not under weighted, not stunted and not wasted) and vaccine coverage, caretaker knowledge, care seeking, mosquito net use, and home management of illness. 95% confidence intervals for concentration indices are also presented. Differences between two concentration indices were tested using a t-test (World Bank (undated)).

Concentration indices take values between -1 and 1. A value of zero indicates that the health variable is equitably distributed across all wealth groups. A negative value indicates disproportionate concentration of the health variable among the poor. Health variables can be “goods” such as intervention coverage, or “bads”, such as mortality or malnutrition. Hence a negative concentration index is pro-poor in terms of intervention coverage, or pro-rich in terms of undesirable health outcomes. (http://siteresources.worldbank.org/INTPAH/Resources/Publications/Quantitative-Techniques/health_eq_tn07.pdf)

9.4 **Results**

In 1999, data were available from 2,006 children under 5 years of age living in 1321 households with children of this age-group in the 120 rural clusters. These represented 93% of eligible households: residents of 137 (6%) were away at the time of the survey and 21 (1%) refused to take part. In the 2002 survey, 1932 children under 5 years of age, living in 1341 households of the same villages were identified. These represented 94% of eligible households: residents of 142 (6%) were away and 9 (0.4%) households refused to take part. The age and sex distribution for these children was similar in the two surveys (Table 1).

Table 13: Age and sex distribution in 1999 and 2002 surveys

Characteristic	Year of survey	
	1999 (N=2006)	2002 (N=1924)
Sex		
Boys	1008 (50%)	980 (51%)
Girls	998 (50%)	944 (49%)
Age in years		
Less than 1	489 (24%)	405 (21%)
1-2	401 (20%)	389 (20%)
2-3	385 (19%)	413 (21%)
3-4	390 (19%)	372 (19%)
4-5	341 (17%)	344 (18%)

Table 2 shows asset ownership in wealth quintiles in the two surveys. There were consistent patterns of assets ownership and socio-economic gradients between IMCI and comparison districts

Table 14: Asset ownership for households in IMCI and comparison districts 1999 and 2002

				Assets, education, household and maternal income										
Year	SES quintile	No. of HHs (%)	Mean asset score	Rented house (%)	Heads education (%)	Mother education (%)	HH income (%)	Bicycle (%)	Radio (%)	Net (%)	Animals (%)	Fowls (%)	Roof (%)	Mother's income (%)
IMCI														
1999	Poorest	132 (22.3)	-1.61	0	44	39	2	8	6	2	9	37	0	0
	Very poor	105 (17.7)	-1.01	0	67	62	4	19	26	7	20	70	4	3
	Poor	119 (20.1)	-0.32	2	76	65	24	41	53	14	10	52	8	7
	Less Poor	119 (20.1)	0.59	3	83	79	52	36	61	35	14	58	31	18
	Least Poor	117 (19.8)	2.45	29	92	83	74	68	77	74	19	55	71	35
2002	Poorest	139 (20.1)	-1.84	0	30	29	2	16	12	9	6	42	3	0
	Very poor	139 (20.1)	-0.88	4	65	53	9	24	35	24	13	56	11	5
	Poor	137 (19.8)	-0.15	1	80	72	16	31	64	49	13	68	18	3
	Less Poor	138 (20.0)	0.72	7	81	72	41	47	75	70	11	65	41	11
	Least Poor	138 (20.0)	2.18	16	97	91	72	54	86	82	14	59	67	48
Non IMCI														
1999	Poorest	123 (20.2)	-1.88	0	68	56	2	3	5	11	2	15	1	0
	Very poor	144 (23.8)	-0.92	1	94	81	8	16	15	49	3	63	2	0
	Poor	98 (16.1)	-0.22	4	91	78	22	40	41	59	8	60	18	5
	Less Poor	123 (20.3)	0.69	9	94	90	40	52	59	81	7	54	28	14
	Least Poor	120 (19.7)	2.51	27	98	97	73	68	77	88	10	59	86	39

2002	Poorest	139 (22.8)	-1.88	0	73	57	1	6	3	49	4	40	1	1
	Very poor	109 (17.9)	-0.90	1	92	84	15	16	24	69	4	61	10	6
	Poor	119 (19.5)	-0.13	3	96	88	22	45	43	84	6	62	29	9
	Less Poor	135 (22.1)	0.80	5	96	96	23	70	73	94	5	87	50	19
	Least Poor	108 (17.7)	2.46	43	98	98	71	67	88	89	11	67	90	54

Table 3 shows the equity results. Six child health indicators (underweight, stunting, measles immunization, access to treated and untreated nets, treatment of fever with antimalarial) improved significantly in IMCI districts ($p<0.05$) in relation to comparison districts, while four indicators (wasting, DPT coverage, care takers' knowledge of danger signs and appropriate care seeking) improved significantly in the comparison districts relative to IMCI districts.

Most concentration indices for the anthropometric variables were negative, showing that the poorest were more likely to be malnourished. For underweight and stunting, inequities declined more markedly in IMCI districts than in comparison districts, that is, concentration indices were less negative in 2002 than in 1999 (Figure 1 and Table 3). The largest improvement was observed for stunting among children between 24-59 months of age; the concentration index improved, from -0.102 in 1999 to -0.032 in 2002, while it remained nearly unchanged (-0.122 to -0.133) in comparison districts. These improvements can be observed in Figure 1, where the gap between the lines representing IMCI and non-IMCI districts increases over time.

The prevalence of wasting was considerably lower than that of either underweight or stunting, and because the analyses were restricted to the children aged 12-23 months, sample sizes were considerably smaller with fewer than 100 children per cell (Table 3). During the study period, wasting prevalence decreased among the poorest in the comparison districts; no cases were

Table 15: Selected outcomes according to socioeconomic quintiles and corresponding concentration indices in 1999 and 2002 for IMCI and comparison districts

Indicator or outcome measure	IMCI	Year	% of children by socio-economic quintiles						Concentration index (95% confidence interval)	
			Poorest	Very Poor	Poor	Less poor	Least poor	*Overall*		
Anthropometric status										
Low weight for age for 0-59 months (Underweight)	No IMCI	1999	38	29	28	23	18	***27***	-0.136	(-0.144,-0.129)
		2002	30	21	15	17	13	***19***	-0.166	(-0.175,-0.157)
	IMCI	1999	31	36	33	29	20	***30***	-0.071	(-0.080,-0.063)
		2002	28	18	24	26	16	***23***	-0.057	(-0.066,-0.048)
Low height for age prevalence in children 24-59 months (Stunting)	No IMCI	1999	65	64	50	46	36	***51***	-0.122	(-0.130,-0.114)
		2002	50	43	43	45	18	***40***	-0.133	(-0.152,-0.115)
	IMCI	1999	69	70	63	50	41	***59***	-0.102	(-0.110,-0.094)
		2002	43	49	46	44	33	***43***	-0.032	(-0.040,-0.024)
Low weight for height prevalence in children 12-23 months (Wasting)	No IMCI	1999	10	15	11	8	12	***11***	-0.022	(-0.061,0.017)
		2002	0	8	6	3	9	***5***	0.217	(0.128,0.305)
	IMCI	1999	14	19	13	14	7	***13***	-0.105	(-0.154,-0.056)
		2002	10	7	6	5	9	***7***	-0.053	(-0.112,0.007)
Coverage of preventive interventions										
Measles vaccination (informed or registered)	No IMCI	1999	86	89	90	88	93	***89***	0.012	(0.006,0.017)
		2002	94	88	91	98	94	***93***	0.008	(0.003,0.013)
	IMCI	1999	90	76	91	88	93	***88***	0.015	(0.008,0.023)
		2002	91	91	87	88	86	***89***	-0.012	(-0.016,-0.007)
DPT vaccination (informed or registered)	No IMCI	1999	74	81	93	90	89	***86***	0.034	(0.025,0.042)
		2002	97	92	100	95	91	***95***	-0.011	(-0.015,-0.007)
	IMCI	1999	90	86	76	90	93	***87***	0.011	(0.003,0.019)
		2002	74	88	82	86	89	***83***	0.030	(0.022,0.038)
Child sleeps under a treated net in the last 6 months	No IMCI	1999	3	3	6	3	13	***6***	0.302	(0.283,0.320)
		2002	5	14	11	14	24	***14***	0.247	(0.231,0.263)
	IMCI	1999	1	0.6	5	5	8	***4***	0.399	(0.380,0.420)
		2002	5	11	9	19	20	***12***	0.260	(0.248,0.271)
Child sleeps under a net	No IMCI	1999	24	27	44	46	65	***42***	0.197	(0.189,0.205)
		2002	48	64	66	73	82	***67***	0.098	(0.092,0.103)
	IMCI	1999	11	5	23	29	39	***21***	0.294	(0.281,0.306)
		2002	25	31	38	54	63	***41***	0.192	(0.185,0.198)
Caretaker knows at least 2 danger signs	No IMCI	1999	17	21	20	32	24	***23***	0.067	(0.057,0.077)
		2002	33	33	36	31	37	***34***	0.018	(0.011,0.024)
	IMCI	1999	22	25	17	20	23	***22***	-0.011	(-0.02,-0.001)
		2002	29	28	30	30	29	***29***	0.005	(-0.001,0.106)
Caretaker's knowledge of feeding during illness	No IMCI	1999	14	21	26	29	23	***23***	0.058	(0.046,0.071)
		2002	22	26	24	32	32	***28***	0.078	(0.071,0.085)
	IMCI	1999	31	28	22	22	27	***26***	-0.040	(-0.05,-0.031)

Indicator or outcome measure	IMCI	Year	% of children by socio-economic quintiles						Concentration index (95% confidence interval)	
			Poorest	Very Poor	Poor	Less poor	Least poor	*Overall*		
		2002	32	29	33	27	28	***30***	-0.029	(-0.034,-0.023)
Management of illness at home or and the facility										
Child with fever receives appropriate treatment	No IMCI	1999	27	40	39	53	64	***45***	0.148	(0.135,0.160)
		2002	18	29	21	30	45	***28***	0.158	(0.136,0.179)
	IMCI	1999	31	40	33	36	53	***38***	0.074	(0.058,0.090)
		2002	24	31	27	25	32	***27***	0.029	(0.015,0.043)
Care seeking										
Appropriate care seeking	No IMCI	1999	31	39	37	49	56	***43***	0.108	(0.010,0.117)
		2002	31	35	34	31	30	***32***	-0.016	(-0.026,-0.005)
	IMCI	1999	35	44	32	46	45	***40***	0.047	(0.039,0.056)
		2002	31	42	35	46	41	***39***	0.055	(0.045,0.064)

observed in the poorest quintile in 2002, and the concentration index became positive. Equity also appeared to improve slightly in the IMCI districts.

Table 3 presents the time trends in inequities in preventive indicators. Unlike the indicators of malnutrition, equity for these outcomes improved when concentration indices were reduced between 1999 and 2002. Measles and DPT vaccine coverage were already fairly equitable in IMCI and comparison districts in 1999, with all concentration indices being very close to zero. Inequity in measles vaccine coverage in comparison districts showed little change (from 0.012 to 0.008), but in IMCI districts the concentration indices changed from 0.015 (slightly pro-rich) to -0.012 (slightly pro-poor).

On the other hand, the overall coverage of DPT in IMCI districts fell from 87% to 83% while it increased from 86% to 95% in the comparison districts (Table 3). The reduction in IMCI districts mostly affected the poorest quintile (among whom

coverage fell from 90% to 74%) and as a consequence the concentration index increased from 0.011 to 0.030. In comparison districts, equity improved (from 0.034 to -0.011) and in fact DPT coverage became slightly pro-poor.

Table 16: Concentration indices: Difference in IMCI and comparison districts

Indicator	Concentration Indices		
	After – before difference (2002 minus 1999)		Difference in differences* (IMCI minus no IMCI)
	IMCI	No IMCI	
Underweight	-0.029	0.014	0.044
Stunting (24-59 months)	-0.011	0.070	**-0.081**
Wasting (12-23 months)	0.239	0.052	0.187
Measles coverage	-0.027	-0.004	**-0.023**
DPT coverage	0.019	-0.045	0.064
Child sleeps under a treated net	-0.139	-0.055	**-0.084**
Child sleeps under a net	-0.102	-0.099	**-0.003**
Caretaker knows at least 2 danger signs	0.016	-0.050	0.066
Caretaker knowledge of feeding during illness	0.020	0.011	**-0.009**
Child with fever received appropriate treatment	-0.045	0.010	**-0.056**
Appropriate care seeking	0.008	-0.124	0.132

* Negative values-indicate greater improvement in equity in IMCI than in non-IMCI districts – are highlighted in bold.

There were significant improvements in the equity of coverage of mosquito nets in both IMCI and comparison districts between 1999 and 2002 (Table 3). The increase was for both treated and untreated nets.

Results on caretaker knowledge are also shown in Table 3. In comparison districts, equity in the proportion of caretakers who knew two or more danger

signs and required urgent health care improved, but no change was observed in IMCI districts where the concentration indices were already virtually zero and therefore highly equitable. Regarding knowledge on the need to continue feeding the child during an illness, there were no significant changes in equity in either set of districts.

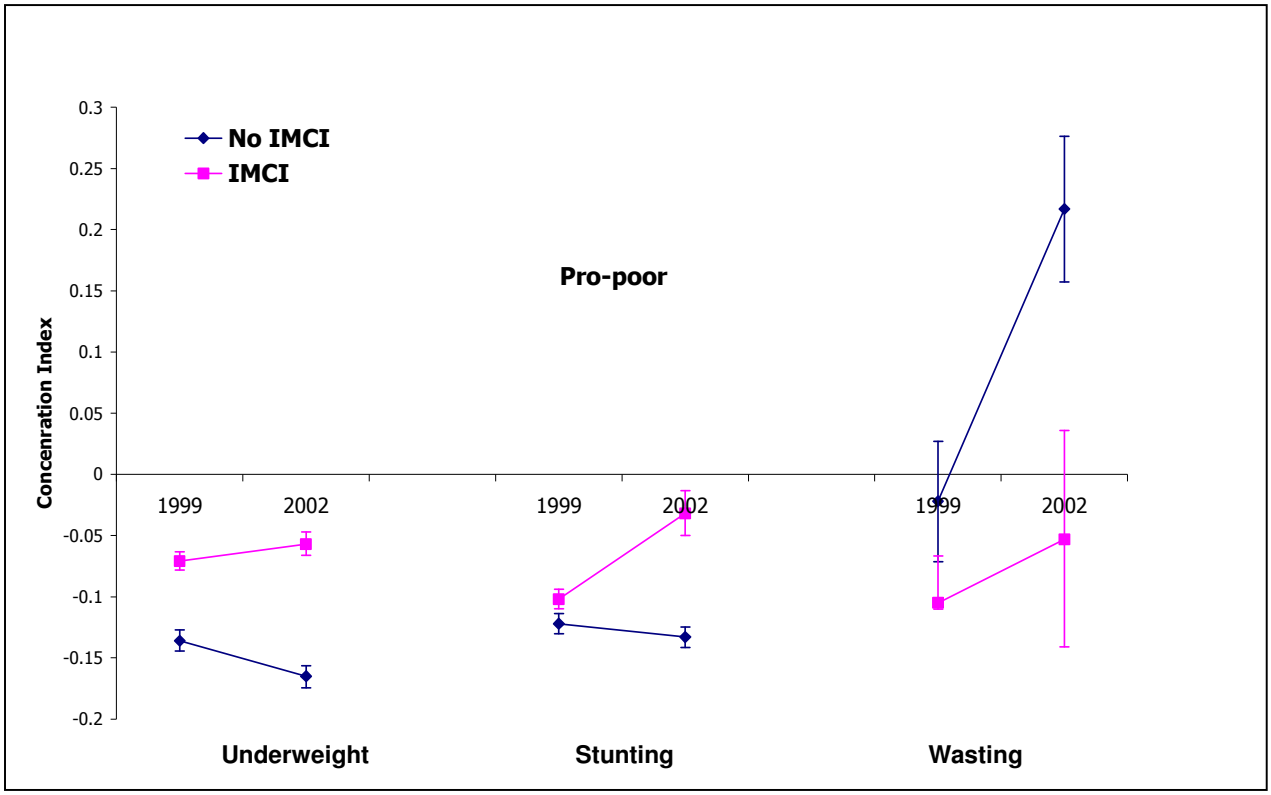

Figure 4: Concentration indices and confidence intervals for nutritional indicators

In terms of case-management, appropriate treatment with antimalarials for children with fever fell between 1999 and 2002 in both IMCI and comparison districts (Table 3). In the former, but not in the latter, equity improved during the study period. The concentration index decreased significantly from 0.074 to 0.029.

Lastly, equity in appropriate care seeking improved significantly in the comparison districts, but the overall care seeking rate fell from 43% to 32% in the period. In the IMCI districts, where care seeking rates were more stable, there was slight but non-significant increase in inequity from a concentration index of 0.047 to 0.055 (Table 3).

Table 4 summarises the equity findings by showing the change in concentration indices (expressed by the difference between the 2002 and 1999 indices) in IMCI and non-IMCI districts, as well as the difference between these two differences. Negative values of the difference in differences – indicating greater improvement in equity in IMCI than in non IMCI districts – were observed for underweight, stunting, measles vaccine, mosquito nets, and fever treatment.

9.5 Discussion

We have used concentration indices based on asset quintiles to measure inequities in childhood health indicators from two independent child health surveys in South East Tanzania. Previous studies have shown that an asset index generated from household assets is a robust proxy measure of wealth (Filmer & Pritchett 2001), and these are now being widely used in the equity literature (Victora et al. 2003).

The main results of the Tanzania MCE-IMCI are presented elsewhere (Armstrong Schellenberg, Adam, Mshinda, Masanja, Kabadi, Mukasa, John, Charles, Nathan, Wilczynska, Mgalula, Mbuya, Mswia, Manzi, de Savigny, Schellenberg, & Victora 2004a). There was an improvement in the quality of care provided in first-level facilities, improvements in some but not all coverage indicators, and a significant reduction in stunting in the IMCI districts compared to comparison districts. Under-five mortality was assessed through demographic surveillance in delimited areas within each district; baseline levels were similar in IMCI and comparison districts, but after two years, mortality was 13% lower in the IMCI districts, a difference that did not quite reach statistical significance.

In a previous analysis of the 1999 survey data, we showed that there were important baseline inequities in nutritional status and in the coverage of key interventions within all four districts (Armstrong Schellenberg, Victora, Mushi, de Savigny, Schellenberg, Mshinda, & Bryce 2003). The question addressed in this paper was whether or not the effects of IMCI mentioned above were associated with higher or lower levels of inequity in short term follow-up.

Stunting is a key indicator because it reflects the cumulative effects of nutritional and infectious factors (WHO 1995). Both stunting and underweight prevalence showed strong inverse associations with the wealth index, as would be expected. Wasting prevalence, on the other hand, tended to be much lower – as observed

in other African settings (Victora 1992), and the association with wealth was modest.

Stunting prevalence declined faster in IMCI than comparison districts, and equity improved more markedly in the former. There were also positive changes with IMCI in terms of underweight. For wasting, baseline inequities were not so marked, and improvement was significantly greater in comparison ($p=0.002$) than in IMCI districts, particularly due to low prevalence among the poorest in these two districts. The possibility of survival bias cannot be ruled out, with wasted children poorest families showing high mortality in the non-IMCI districts where death rates were higher. Overall it seems that IMCI had a beneficial impact on equity in nutritional status.

Results on vaccine coverage were mixed. IMCI was associated with improved equity for measles vaccine, whereas the opposite was observed for DPT. A potential caveat is that we relied both on information recorded on a vaccination card as well as on doses reported by the mother; nevertheless, the same procedure was used both in IMCI and non-IMCI districts. These results concur with earlier findings (Armstrong Schellenberg, Adam, Mshinda, Masanja, Kabadi, Mukasa, John, Charles, Nathan, Wilczynska, Mgalula, Mbuya, Mswia, Manzi, de Savigny, Schellenberg, & Victora 2004a): the introduction of IMCI was associated with a drop in DPT coverage of a few percentage points, of statistical rather than

public health significance. Nevertheless, these disparities highlight the need to reach the poorest children with this vaccine.

In terms of mosquito nets, equity improved in all districts. The decline in inequity of coverage for children sleeping under a treated net was faster in IMCI districts compared to comparison. It should be noted that the two comparison districts (Kilombero and Ulanga) were covered by a social marketing programme of treated nets that started two years earlier than in the IMCI districts (Nathan et al. 2004).

For indicators on caretaker knowledge and care seeking behaviours, the picture was also mixed. IMCI districts did better in terms of the proportion of caretakers who knew child health danger signs and in management of fever with antimalarials. On the other hand equity improvements were greater in comparison districts for care seeking rates, but this was largely due to a reduction in appropriate care seeking rates in the two upper quintiles in these districts, rather than an improvement among the poor. Reasons for these reductions are unclear, although they may be due in part to the change of first-line antimalarial drug from chloroquine, which was both popular and easily available to the rather less popular sulphadoxine-pyrimethamine, which was less widely available.

This study has shown how equity assessments can be incorporated in impact evaluations at relatively little additional cost, and how these may point to specific interventions that need to be reinforced. For example, whereas vaccine coverage is reasonably high and equitable, there remain important inequities in mosquito net coverage and in treatment of fever with antimalarials.

In the study districts, IMCI consisted mainly of the training of health workers, in a context of support to district management by the Tanzania Essential Health Intervention Package (Armstrong Schellenberg et al. 2004b). One might fear that the absence of a strong community component for promoting IMCI at household and family level might lead to increased inequities, because access to health facilities was already inequitable when IMCI was introduced (Armstrong Schellenberg, Victora, Mushi, de Savigny, Schellenberg, Mshinda, & Bryce 2003). Such apprehension was not confirmed by our data. Therefore, IMCI introduction led to improvements that did not occur at the expense of equity. These findings should be interpreted in the light of two important characteristics of rural Tanzania: the relatively high rates of utilization of government facilities (Victora et al. 2005) and the fact that no user fees are charged in the two districts implementing IMCI (Manzi et al. 2005).

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PART IV: DISCUSSION AND CONCLUSIONS

CHAPTER 10: Discussion and Conclusions

This chapter discusses the main findings of the collected work presented in this thesis (Chapter 2). Methodological strengths and weaknesses of studies conducted and their relation to other studies are also discussed. Implications of the study findings are summarized with a view to how they can inform policy and consequently improve child health and survival. Emerging questions and future work are also proposed.

We are almost at the halfway mark since commitment was made by world leaders to resolve most pressing problems of humanity and it is therefore important to take stock of what we have achieved so far. Have we made reasonable progress with the coverage of technologies we have at present? What are the bottlenecks to achieving these goals? Can we do better, for history not to condemn us for not meeting our obligations? This thesis is a compilation of studies that are aimed at addressing some of the information and knowledge gaps by tracking progress on causes of death, intervention and health systems evaluation, and impact and equity assessments of large interventions programmes.

Burden of disease

Since the publication of the Global Burden of Disease (GBD) study in 1993 (Murray & Lopez 1996) which quantified the causes of deaths and injuries and the associated risk factors in eight regions of the world, there have been increased investments led by the World Health Organization (WHO) on improving the conceptual, methodological and empirical basis of assessment of burden of disease and injury burden.

There is also an increasing demand for cause specific mortality burden data by planners of health services for allocation of resources to different intervention strategies to maximize their impact. Further, international aid donors need this information for assigning priorities for support and for accountability. However, in countries where disease burden is greatest and resources available for health services are insufficient, less priority has been given to collecting morbidity and mortality data. Such data are often patchy in their coverage, and are usually related

to urban populations, consequently the planner of health services who is bestowed with the task of assigning resources to different interventions to maximize impact, lacks this basic quantitative information to guide him or her through this process.

A very basic step in understanding the demographics of populations and their health in any country is the counting of births and deaths and understanding what its members die of and at what age. Such data, even without the associated morbidity, would present a huge step towards assessing disease burden in poorest communities. Efforts to improve the collection and harmonization of vital statistics in resource poor settings are being spearheaded by the International Network for Demographic Surveillance (INDEPTH) and the Health Metrics Network (HMN).

A stepping stones approach to a vital statistics system has been proposed for countries without reliable vital statistics (HMN Figure). Step one would use sentinel registration with a minimum of at least one urban and rural demographic surveillance site each. This will provide the number of births and deaths by age, sex and cause in a sentinel sample the population but would not be fully representative of the whole country. Quality ascertainment and adjustments of data would be an on-going process. Step two would add simple random cluster sampling methods with enough clusters for representative analysis of sub-national burdens of disease (e.g. state, regional or provincial level) once a country is ready to move on to a more costly approach.. It is envisaged that steps one and two would provide valuable interim vital statistics while waiting for routine civil registration systems to build up quality and coverage to the required level of at least 90% coverage. At that time the sentinel and sample systems could be decommissioned.

Demographic surveillance combined with mortality surveillance using verbal autopsy (VA) has the potential to provide useful mortality data in these settings where as much as 80% of the disease burden is due to years of life lost to premature death. In our study on cause specific mortality we have provided cause-specific mortality rates for more than two years period (2000-2002) for Kilombero and Ulanga districts. As more data on causes of death is becoming available, global burden of disease estimates have also been published and are expected to provide the necessary impetus of the interventions needed to reduce them. The major killers of children

younger than five years have remained the same. Malaria, pneumonia, diarrhoea, nutritional deficiencies and conditions arising during the perinatal period were the leading causes of death in Kilombero and Ulanga districts. Our results are consistent with two reports on global estimates by the WHO Child Health Epidemiology Reference Group (CHERG) (Bryce et al. 2005) and by Lopez and colleagues (Lopez et al. 2006) both showing similar findings that more than half of these deaths were from preventable or treated conditions.

If the health related Millennium Development Goals (MDGs) and especially goal number 4: to reduce child mortality are to be meet, careful and well designed approaches are required to prevent and control these conditions. Experience from neighbouring districts of Rufiji and Morogoro Rural where similar demographic and mortality data were collected and integrated into resource allocation for health care have shown impressive results. Health services profiles introduced by the Tanzania Essential Health Interventions Project (TEHIP) were generated annually from cause-specific mortality data and provided to members of the council health management

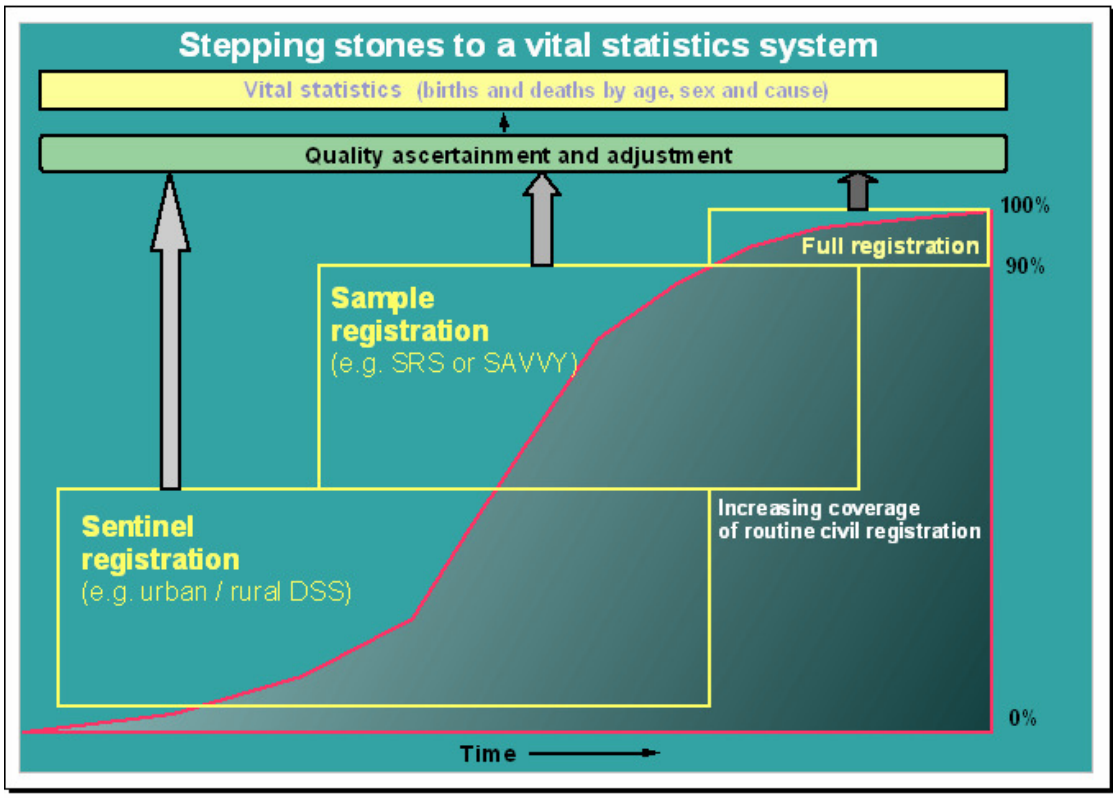

Figure HMN Stepping stone approach to vital statistics system

teams (CHMTs) during their annual planning. The CHMTs used the burden of disease information to set intervention priorities, chose a shorter list of essential health interventions, and align resources to interventions that addressed the biggest share of the burden in their respective districts.

In a recent global analysis, HIV/AIDS which accounted for only 2% of deaths in 1990 is responsible for 14% of global mortality in 2001. HIV/AIDS was the leading cause of disease burden in Sub-Saharan Africa, where it was followed by malaria (Lopez, Mathers, Ezzati, Jamison, & Murray 2006). Our results though could be an underestimate of the actual burden, indicate an increasing problem due to HIV/AIDS especially in the most productive age group (15-49). With the exception of infants, HIV/AIDS was among the top ten leading causes for death in our study. The global analysis referred to above, which is based on modelling a variety of source of information, suggests that in Africa, diarrhoea and malaria are equivalent components of the burden of disease, each with shares of about 18% of the total. However in the DSS data in Tanzania and elsewhere in Africa, diarrhoea is recorded much less frequently than 18% as a component in the burden of disease, while malaria is recorded much more frequently than 18% in every setting examined. This calls into question the difference from directly measured empirical data as seen in DSS settings and the basis of the models currently used for Burden of Disease analysis by WHO.

Health system access

A central problem in establishing health care systems is to provide resources in locations that are close enough to be reached by the populations in need. Therefore, ensuring physical accessibility and provider-consumer links is of primary concern. Physical distance between provider and consumer has been recognized as an important barrier for several decades (King 1966) and studies have shown that most people will not travel further than 5km (one hour walking) to basic and curative care (Stock 1983) . The distance problem seriously affects women and their children in the uptake of health services. By virtue of their reproductive functions and the their role in children care, women are more likely to seek more frequent health care than males

Results from our study show that, spatial patterns of access to health care for children younger than five years and pregnant women were very similar indicating use of health facilities close to their households. About 78% of this rural population were shown to be within 1 hour from a health facility. Average travel time to a health facility for both under five and maternal care was estimated as 36.5 and 36.8 minutes respectively. In a similar setting in Kwazulu Natal, where the road network is fairly advanced 65% of the residents of homesteads travelled an average of 1 hour or more to attend the clinic (Tanser, Gijsbertsen, & Herbst 2006). Similarly, a study in four rural districts in Kenya estimated that 63% of the population were within 1 hour of the national access benchmark (Noor et al. 2006). Tanzania therefore appears to have a much more physically accessible health system than these wealthier countries.

Since independence, Tanzania's policies have been geared towards improving social development which includes health. In the different waves of reforms that the country has gone through, proximity to health services in the rural areas where the majority of the population live has been one of the primary concerns of the government. The policy of ensuring that at least every village in the country had a primary health care facility was hence adopted. Due to the decline in physical infrastructure of the health system in the 1990's it was important to obtain more accurate estimates of current access to health services as a crucial parameter for understanding coverage of different health interventions. Such evidence is lacking in the current health information system in Tanzania.

Attraction to government facilities as estimated by the distance usage index (DUI) was higher in government health facilities compared to the non-governmental mission dispensaries nearby. We did not collect information on quality of health services during this study and hence cannot claim the resulting attraction as due to quality. However, there was strengthening of case management and improvement in the health systems capacity to support IMCI implementation in the district before and during the period of our study. Quality of health care has also been shown in other studies to have more impact on utilization than physical access (Acharya & Cleland 2000;Egunjobi 1983).

Health system interventions

The Integrated Management of Childhood Illness (IMCI) is one among many strategies for improving child health that integrates several interventions, each of which have already been proven to be efficacious in randomized controlled trials. There was a need therefore of evaluating their combined delivery under routine implementation conditions. The Multi-Country Evaluation of Integrated Management of Childhood Illness MCE-IMCI is an evaluation of this strategy that included studies of the effectiveness, cost and impact of IMCI in Bangladesh, Brazil, Peru, Tanzania and Uganda (Bryce et al. 2004). The IMCI strategy is comprised of: 1) improving health systems to support IMCI;, 2), improving health workers skills to manage major causes of illness in children younger than five; and 3) improving family and community practices needed to prevent diseases and stimulate appropriate utilization. In our study, we studied districts that implemented the first two components of the strategy. Guidelines for implementing the third component were not available in the duration of the study.

Evidence from our work shows that facility based IMCI improved quality of care (chapter 6) and was associated with a reduction in mortality (chapter 6). Mortality was 13% lower in the intervention than in comparison districts (Chapter 6). The costs of IMCI were similar or lower in intervention than in comparison districts (Adam et al. 2004) and more important the introduction of IMCI led to improvements in child health that did not occur at the expense of equity (Chapter 8).

In our study the presence of demographic surveillance systems in each of the four districts was used to define the population at risk and determine mortality events. This enabled us to define individual risks and made it possible to measure person time at risk. With the exception of the study in Uganda where no evaluation on mortality was done, other MCE study sites used different methods to evaluate child survival. For instance in Peru (Huicho et al. 2005b) they used the birth histories from two demographic and health surveys (DHS), while in Brazil vital registration and community health workers demographic surveillance (Amaral et al. 2005) were used to calculate mortality rates. The study in Bangladesh which is expected to finish in 2007 is expected to use similar methods to ours with mortality data provided by the Matlab DSS.

Demographic surveillance systems (DSS) allow the tracking of migrations. Migrations are very common at least in this part of Tanzania and their integration into the DSS makes it possible to define individual time at risk. Tracking of migration is also critical in longitudinal studies and vaccine trials. Such tracking and use of accurate person-time denominators means that rates and trends measured in DSS are much more reliable than other sources. This makes the DSS setting useful as a testing ground for impact and health systems evaluations such as done here for IMCI.

Our results on improved quality of care are consistent with those from other four studies in Uganda (Gouws et al. 2004), Peru (Huicho et al. 2005a), Brazil (Amaral et al. 2004) and Bangladesh (el Arifeen et al. 2004) even though case management training in some the sites was of minimum standards of quality.
In our study districts, the 11 and 16 day courses for clinicians and non-clinician respectively and follow up after training was critical in reinforcing the skills gained during the training. An integrated supervision approach which has been introduced is expected to improve quality and performance of health care provision.

Among the contributing factors of success of our study was the presence of system strengthening activities in the study districts. From the onset of IMCI introduction in Tanzania, health system strengthening activities by TEHIP were already underway. TEHIPs system strengthening activities that included a set of simple, user-friendly tools to enable local-level health planners to plan on the basis of evidence (de Savigny et al. 2004), from which the districts chose to implement IMCI and other key interventions.

One of the assumptions of the IMCI impact model was that improvements in child health and nutrition depended on improved quality of care in health facilities which in turn would improve care seeking and utilization or increased coverage rates of key family interventions. Utilization rates reported from one of our baseline studies indicated that 41% of all the children who reported an illness two weeks preceding the survey sought care from a public health facility (Armstrong Schellenberg et al. 2003). These rates are higher than those reported from similar studies in Uganda

and Bangladesh where 8% and 13% of children reported to have sought care from a public health within two weeks preceding the survey respectively..

The biggest cost share in IMCI implementation goes to training of health workers. The total district-level financial cost is estimated at 20.5 million shillings per district, or a total of 2.5 billion shillings for the whole country excluding the costs of introduction of burden of disease and health mapping tools[2], a sum most of the districts would not have afforded earlier. With decentralization, districts now have more autonomy and control over their health budgets and plans. More money is now available from Sector Wide Approach (SWAp) health basket funding and other sources such as the local government and revenue generated from cost-sharing.

There a number of challenges on how best to accelerate implementation of IMCI in the country. It has been observed that coverage is growing at a slower pace than anticipated. 43 out 121 districts of mainland Tanzania and 4 out of 10 districts in Zanzibar have not started implementing IMCI despite the districts receiving funding and orientation from the central level.

Vitamin A supplementation

Interventions, however effective, are not enough if they do not reach the poor children who need them most. Vitamin A supplementation is considered to be one of the most cost effective interventions that have been researched extensively both in terms of health and nutritional impact and in terms of ways to make supplementation programmes successful (Sommer & West, Jr. 1996). During the IMCI evaluation, we documented an increase in vitamin A supplementation coverage from 13% to 76% in 1999 and 2002 respectively that was sustained by repeated campaigns for three years without compromising equity (Chapter 7). Our results are similar to those reported in the Phillipines (Choi, Bishai, & Hill 2005) where they examined VAS in the last six months using DHS data in 1993 and 1998.

[2] Evaluation of facility based IMCI in Rufiji and Morogoro Districts, Tanzania. *Policy Brief, March 2004*

Twice yearly mass campaigns were introduced since 2001 to catch up with the low coverage rates in children between 6-59 months of age supplemented through the routine EPI system. Under the routine system, children are scheduled to receive their vitamin A supplementation at the time of their measles vaccination at 9 months and at 15 and 21 months. Coverage rates during these routine contacts have been low, necessitating the initiation of twice yearly supplementation campaigns that are coupled with activities on the Day of the African Child in June and the World AIDS day in December. Moreover, routine supplementation did not consider children above 2 years of age but less than five years who would also benefit from such an intervention. Reports on the benefits of VAS below 6 months of age have been less consistent than from those above 6 months old (Humphrey et al. 1996;Rahmathullah et al. 2003;WHO/CHD Immunisation-Linked Vitamin A Supplementation Study Group 1998) resulting to varied consensus on the policy recommendations by the expert group on vitamin A supplementation.

Kilombero Vitamin A supplementation study

In our study to evaluate the safety and efficacy of two vitamin A supplementation schedules in infants in Kilombero district in southern Tanzania (Chapter 9) high dose vitamin A was found to be safe and well tolerated by both mothers and infants. However, this did not confer any benefit in terms of reducing the incidence of disease in infants in the higher dose group. The prevalence of vitamin A deficiency at 6 months of age was 43% in the higher dose group and 47% in the lower group. Our results are contrary to what was found before (Humphrey & Rice 2000) and it was necessary to consider all possible explanations. In general, vitamin A supplementation results from studies in children less than six months have been less consistent than those documented for supplementation later in life (Fawzi 2006). In similar studies in Indonesia (Humphrey, Agoestina, Wu, Usman, Nurachim, Subardja, Hidayat, Tielsch, West, Jr., & Sommer 1996) and India (Rahmathullah, Tielsch, Thulasiraj, Katz, Coles, Devi, John, Prakash, Sadanand, Edwin, & Kamaraj 2003), large doses of VAS in neonates had beneficial effects in children of normal and low birth weight respectively.

We noted a degradation in the quality of some vitamin A capsules and excluded these children in the analysis. The results however remained unchanged but pointed

the need to institute quality control measures in clinical trials and in current supplementation programs.

Health equity assessment

Assessments of inequalities in health have become increasingly popular in public health literature. As there is more emphasis now on devising new delivery strategies and increasing coverage of available interventions, it is imperative that these efforts go hand in hand with ensuring that gaps do not increase and that coverage between the rich and poor is equitable.

In our study, introduction of IMCI was associated with an improvement in child health. But there was still the question of whether this widened the gap between the richer and the poorer children and we therefore sought to find out whether the introduction of IMCI was associated with any equity differentials that are important to address when scaling up such interventions (Masanja et al. 2005). Although there might be fears that the absence of a strong community component for promoting IMCI at household and family level might lead to increased inequities, because access to health facilities was already inequitable when IMCI was introduced (Armstrong Schellenberg, Victora, Mushi, de Savigny, Schellenberg, Mshinda, & Bryce 2003). Such apprehension was not confirmed by our data. Therefore, IMCI introduction led to improvements that did not occur at the expense of equity.

To our knowledge our results on equity differentials in child health were the first within the MCE framework. Other MCE sites either evaluated inequalities in health at one point in time or did not evaluate at all.

In a previous assessment when IMCI implementation was still in the phasing in stage, we showed that there were important inequities in nutrition and coverage of key interventions within all the four districts (Armstrong Schellenberg, Victora, Mushi, de Savigny, Schellenberg, Mshinda, & Bryce 2003).

We used concentration indices based on household assets to assess inequalities in access and coverage of child health interventions. This proxy wealth index measures the extent to which a particular health variable is distributed unequally across all five

wealth quintiles. Other studies that have also used similar methods to ours are those commissioned by the World Bank in over forty countries including Tanzania, to measure inequality in health, nutrition and service used among individuals of different socio-economic classes (Gwatkin et al. 2000). Concentration indices have also been used to measure Although the wealth index lacks a straightforward interpretation in intuitive units, concentration indices and concentration curves have become fairly standard measurement tools in health economics literature on equity, inequalities health and health care. Another measure of health inequality that is frequently used is the rich-poor ratio which compares extreme groups and ignores middle quintile groups.

Review of the designs

As in most studies, there are important limitations that need to be taken into account. Although limitations for each study design were presented in individual chapters of the thesis, further aspects of the designs are discussed here.

Burden of disease

The Verbal Autopsy (VA) is a crude method of determining causes of death in countries where like Tanzania where vital registration is incomplete. But it is the best available alternative. The process of arriving at a probable cause of death begins from the interview with a relative or family member who took care of the diseased to a panel of physician or a computer algorithm using the WHO International Classification of Disease ICD-10 or similar. In our study we used lay field workers to collect information from the relatives on the causes leading to death and requested for any hospital documentation such discharge summaries or death certificates available. This was further reviewed by a panel of physicians without using pre-defined diagnostic criteria to arrive at a final cause of death.

Although this method of physicians review without pre-defined diagnostic criteria has several advantages, such as validity of VA diagnosis of selected causes being better than algorithms and also less VA interviews being classified as undetermined relative to other methods, it was also bound to some limitations. The major limitations which our results also suffer from this method have been reported. They include: 1) low repeatability of the diagnoses reached by physicians (Todd et al. 1994); and 2) the difficulty of sustaining physician interest and diagnostic

consistency over long periods. Other operational problems associated with physician coding is the cost and time delays incurred.

Some causes of death (COD) could not be captured through the VA alone and hence supporting documents were required to arrive at a possible cause of death. In our study, VA interviewers requested from the respondents documents such as admission cards and laboratory tests that belonged to the deceased if he or she ever came into contact with formal health care providers. Although this improves the accuracy of the COD reached by VA, it makes comparisons between populations difficult. This implies that proportional mortality of causes that cannot be diagnosed using the symptom or sign checklist history will be underestimated in rural compared to urban settings. Results from our study showed that slightly more than half of the deaths occurred at home and most probably some without any contact with a health care provider and therefore are less likely to have any documentation which their urban counterparts are more like to have.

Although the use of diagnostic criteria is beyond the scope of this thesis, it is worth mentioning that the procedure is much more transparent and repeatable. Bayesian probability methods have been used to assigning causes of deaths and have shown comparable results to physician reviews (Byass et al. 2006;Fantahun et al. 2006). However the methods are yet be validated against a “gold standard” other than the COD reached by physician review. In a new development, King and Yang have demonstrated that the difficult assumptions underlying the present methods could be overcome by allowing more causes to be analysed simultaneously (King & Lu 2006). This approach sounds attractive and easier to use in practice than the physician reviews, expert algorithms and parametric statistical assumptions.

Our results are also susceptible to the bias due to misclassification of causes of death within subgroups for instance deaths between malaria and other infectious diseases such pneumonia or meningitis. It is further argued that inadequate information could lead into overestimating or underestimating.
We did not attempt to adjust for bias due to misclassification in our study and therefore caution should be exercised when interpreting the result. Ways of dealing with misclassification errors have been suggested (Chandramohan, Setel, & Quigley

2001) and have shown provide reliable cause-specific mortality fractions for diseases of public health importance (Setel et al. 2006).

As VA experts are in the process of agreeing on using standardized VA instruments and COD lists that will allow global comparison it is important to clear some definitions that will disfavour this analysis such as the definition of children and adults. In our study, three questionnaires, one each for deaths at 0-28 days, 29 days to less than 12 years and above 12 years were used to distinguish neonatal, child and adult deaths respectively. Other sentinel sites in Tanzania have used AMMP questionnaires which categorized neonates, children and adults into 0-28 days, 29 days to less than 5 years and more than five years age groups respectively. The proposed tools from the group of VA experts is likely to solve some of these problems in the short to medium term

Health systems access

A major limitation in our study on spatial access to health care by pregnant women and children younger than five was the failure to incorporate natural physical barriers such as land cover and land use in our travel time model. Travel time over open country was assumed to be the same as travel time along the smallest path or track lending our model potentially to underestimate the actual travel times between households and health facilities if there are major obstacles in the open countryside. We also made educated guesses on the travel speeds on different road levels and on modes of transport which may not apply uniformly to every household or health seeker.

Health systems interventions

Epidemiology classifies the randomized controlled trial as the “gold standard” because they are not affected by the usual pitfalls of selection or information bias, confounding or chance. A randomized design was impossible in our case since the IMCI was already being implemented in two of the four districts that were included in this study. However, we made all possible efforts to document all potential activities in the districts that would have affected our impact results. The evaluation in Bangladesh is using a randomised design with half of 20 first level health facilities assigned to implementing IMCI and half are comparison.

Chapters 6, 7 and 8 present studies that were conducted during the evaluation Integrated Management of Childhood Illnesses (IMCI) in Tanzania. We used non-randomized control trial or plausibility design (Habicht, Victora, & Vaughan 1999) in which there is monitoring of process measures to improve the internal validity of the study and of contextual (or external) factors to check whether any apparent effect of the intervention can be explained by other factors.

The IMCI study evaluated the effectiveness of the integrated delivery of a number of individually well proven child health interventions delivered under real life conditions. IMCI in the study districts was managed and implemented by district health management teams since 1996. The first component of IMCI emphasizes proper case management of sick children using stipulated guidelines. Since implementation was already underway when the evaluation commenced in 1999, we were not able to do a before and after comparison that would have strengthen our hypothesis on impact of IMCI on mortality. Nonetheless, we were reassured from sub-national DHS mortality results that child mortality levels in intervention districts were similar to or worse of than comparisons districts at the commencement of the study.

Vitamin A supplementation

The MCE-IMCI study provided an opportunity to evaluate the coverage of other intervention such vitamin A supplementation and insecticide treated nets. UNICEF supported the national delivery programme of vitamin A supplementation through twice annual campaigns since 2001. To our knowledge, no records outside routine contacts are registered on the child's MCH card. In our study, we depended on a large extent on mothers' recall of vitamin A supplementation status of their children. Although we checked for this information on the children's card, it was of limited use since the campaign staff were not trained to record vitamin A. Results from immunization studies using mother's recall are mixed. In Kenya for instance they found sensitivity of mother's recall was high but declined with the numbers of vaccines (Ndiritu et al. 2006). In another study in India, the found that maternal recall to have a low sensitivity (Ramakrishnan et al. 1999).

Kilombero vitamin A supplementation

We were unable to use a placebo in this study because of ethical concerns of the marginal benefits of the lower dose regimen (25,000IU) of vitamin A in children younger than six months in a previous trial. It can still be argued though, that the use of a placebo would have increased the efficacy estimate of our study as there was no chance that the lower regimen would ever be widely implemented during the course of the study.

A major strength of our study was the use of passive case detection (PCD) to detect safety signals and the potential effect of the intervention on morbidity for a longer period of time. This ensured that cases severe enough to require the attention of more qualified health personnel were attended during the follow up rather than the two days after supplementation.

Policy Implications

Tanzania started implementing IMCI in 1996 with a focus on strengthening the health system, improving health workers' skills in case management, and improving household and community practices for child survival, growth and development albeit at later stages. Facility-based IMCI has shown to improve quality of care, to reduce mortality in children younger than five and not costing more than conventional care. These results were a basis of adopting the strategy nationally and promoting it for all district health plans (IMCI/NMCP meeting Dodoma). While we appreciate the challenges of how best to accelerate implementation of IMCI in the country, it is discouraging to note that the scale-up is going at a slower pace than anticipated. The costs for introducing IMCI are affordable with the funds the districts have. Districts are encouraged to make this modest investment that has the potential to save the lives of more than 223,000 children younger than five each year. One reason the uptake of IMCI in all districts has been slow could be that the TEHIP tools that drove the uptake in our studies (Burden Profiles and District Health Accounts, both using the DSS sentinel data) had until 2006 not been available to all districts. The lessons of TEHIP in Rufiji and Morogoro Rural districts on using evidence to guide decentralized planning of the health sector are important to help districts plan better for additional resources once they become available. In February 2006, the TEHIP

District Health Accounts and Burden Profiles have been incorporated into national planning software for districts and rolled out to more than 120 districts of mainland Tanzania using a planning and reporting tool (PlanRep) designed by the Ministry of Finance and the President's Office, Regional Administration and Local Government (http://www.poralg.go.tz/mis/planrep.php). This should now make it easier to accelerate the prioritization of the most effective health interventions including IMCI in all districts of the country.

Tanzania is in the expansion phase of mainly the first two components of the strategy within implementing districts, to new districts and in pre-service training institutions. Expansion of IMCI to other districts has been possible because of a number of enabling factors including the government's commitment to reducing the overwhelming burden of morbidity and mortality among children younger than five years. IMCI is now an integral part of the national package of essential intervention. Basket Funds from the Sector Wide Approach (SWAP) partners are now available to the districts and they are at liberty to tap them for IMCI implementation. Over time, more partners have joined to support the MoH in implementing the strategy. These include the first five key partners WHO, UNICEF, TEHIP and the Word Bank. Others now on board include NGOs, bilateral organization and foreign agencies.

The third component i.e. community IMCI is being implemented in seven pilot districts. Lessons from the implementation are expected to be expanded to remaining districts. So far, two NGOs are involved in the implementation of community IMCI. It is widely acknowledged that government reforms on increased community participation in health service delivery through local governments and HSR will be particularly helpful for the community component.

Sustaining the positive changes and scaling up of IMCI implementation are crucial in ensuring continued reduction in morbidity and mortality among children. A number of measures have been taken to ensure best practices are sustained and scaled up. These include IMCI is now an integral part of the district plans

A concern about the stability of vitamin A capsules in our study merits careful consideration especially during the mass vitamin A supplementation campaigns

events that have been in effect since 2001. Undoubtedly, vitamin A has been rigorously evaluated in different settings and proved to reduce mortality in children between 6 months and five years of age. However, stringent and frequent quality control measures on the potency of the capsules need to be done by the relevant authorities if the benefits vitamin A supplementation confers are exploited to the maximum. The urgency to reduce child death needs to be balanced with sound evidence from studies conducted in difference settings. Our findings did not support the current recommendations by the International Vitamin A Consultative Group (IVACG) on the high dose regimen and this raises important questions on adopting such recommendations into national policies without sufficient clinical evidence to support them.

Future work

There is huge as yet untapped potential in Tanzania's Demographic Surveillance System. The sites still need to be joined into a national sentinel system. Information on land use and land cover will form an important part in further understanding spatial access to equitable health care in rural settings in Tanzania. The wealth of data that has already been collected from the DSS has the potential to allow further analyses such as coverage of health services, equity effectiveness and to assess household mobility between wealth quintiles over time, as well as the performance of the health system under new strategies of poverty reduction and scaled up health interventions.

Conclusion

Some key lessons from this work are:

- Knowledge of causes of death can lead to more rational choices of interventions and delivery strategies that have the greatest impact on child survival
- Strengthening of the health information system to include real time, population based burden of disease information from sentinel populations vital for tracking progress and trends in child survival.
- Change in delivery strategy has a potential to quickly increase coverage of interventions, however, care needs to be exercised that the strategy does not undermine other essential health programmes.

- Evidence of improvements in child health and survival linked to IMCI at no extra cost supports a policy of more investments and expansion in the IMCI strategy.
- The marginal cost of incorporating equity assessments of access and health outcomes in impact evaluation is low.
- The use of empirical evidence as the basis for informing policy rather than just theoretical calculations and extrapolations from out-of-date data, retrospective surveys or models needs to be given more prominence

We have used a set of studies employing different methodological approaches that show that mortality reduction in children younger than five is feasible in a low GDP setting with interventions that are available today. The national challenge is scaling up these interventions to reach more than 223,000 children who die annually from preventable conditions including, malaria, pneumonia, diarrhoea, measles and malnutrition in Tanzania and approximately 6 million worldwide. The global challenge is scaling up these interventions to reach more than 6 million children who die annually from preventable conditions including, malaria, pneumonia, diarrhoea, measles and malnutrition in just 42 countries accounting for 90% of child deaths worldwide.

Key messages

1. In the absence of complete vital registration, data collected from carefully selected sentinel sites can assist in understanding the magnitude of burden of disease and poverty conditions that is necessary to inform national health policies, allocation of resources, equity of the system, monitoring and evaluation, and trends in progress toward national and international goals.
2. Evaluation of the impact of large-scale public health interventions programmes needs to go beyond classical randomized controlled designs and requires ample time to demonstrate measurable impact results in real health systems.
3. Strong health systems are necessary for both implementing and evaluating national health policies and their effect on health status. More focused

investments in strengthening health systems is likely to improve health and meet the time-bound goals to which we have committed ourselves.

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