PN-ABF-946

REPORT ON THE COST-EFFECTIVENESS OF THE EXPANDED PROGRAM OF IMMUNIZATION IN THE REPUBLIC OF SUDAN

VOLUME IV: Middle Region

February 1990

USAID/Khartoum

Resources for Child Health Project

REACH

John Snow, Inc.
1100 Wilson Boulevard, 9th Floor
Arlington, VA
22209 USA
Telex: 272896 JSIW UR
Telephone: (703) 528-7474

PN-ABE-946

REPORT OF COST-EFFECTIVENESS STUDY OF THE EXPANDED PROGRAMME OF IMMUNIZATION IN THE REPUBLIC OF SUDAN

VOLUME IV: MIDDLE REGION

April 1989
(revised February 1990)

Ahmed Babiker, Finance and Administration Section, EPI
Michael Enright, REACH
Logan Brenzel, REACH

Prepared by the Resources for Child Health (REACH) Project
USAID Contract No. DPE-5927-C-00-5068-00

TABLE OF CONTENTS

LIST OF TABLES ii

ACRONYMS iii

ACKNOWLEDGEMENTS iv

EXECUTIVE SUMMARY 1

I. Introduction 3

II. Organization of the EPI in Middle Region 4

III. Methodology 7

IV. Results for Mobile Teams and Fixed Facilities 15

V. Conclusions and Recommendations 34

APPENDIXES 36

1. Itinerary of Field Activities in Middle Region
2. Persons Contacted
3. Summary Tables
4. Background Tables

LIST OF TABLES AND FIGURES

II.1 Comparison of Coverage Rates for Children Less Than One Year of Age 1987-88 in Middle Region 7

III.1 Delivery Sites Sampled for the Cost-Effectiveness Study in Middle Region 13

IV.1 Cost of the EPI for Mobile Teams in Middle Region 16

IV.2 Indicators of Activity for the Mobile Teams in Middle Region 19

IV.3 Sites for Mobile Team Activities in Middle Region 21

IV.4 Drop-Out Rates for Mobile Teams: Middle Region 23

IV.5 Vaccine Wastage Rates for Mobile Teams in Middle Region 23

IV.6 Classification of Mobile Teams in Middle Region by Cost/FIC 24

IV.7 Comparison of Mobile Teams in Middle Region 25

IV.8 Comparison of Health Facility Costs in Middle Region . . . 27

IV.9 Indicators of Activity at Health Facilities in Middle Region 29

IV.10 Comparison of Drop-Out Rates for Health Facilities in Middle Region 30

IV.11 Comparison of Wastage Rates Among Selected Facilities in Middle Region 31

IV.12 Classification of Health Facilities in Middle Region by Cost/FIC 32

IV.13 Health Facilities: Indicators of Cost and Effectiveness 33

IV.14 Comparison of Annual Costs by Strategy 34

FIGURES

Map of Middle Region 12

IV.1 Cost Profiles: Mobile Teams in Middle Region 17

ACRONYMS

BCG	Bacillus Calmette-Guerin vaccine against tuberculosis
CDD	Control of Diarrheal Diseases Program
DOO	District Operations Officer
DPT	Diphtheria-Pertussis-Tetanus vaccine
EPI	Expanded Programme of Immunization
FTE	Full-time Equivalent
HAOO	Health Area Operations Officer
NGO	Non-governmental organization
OPV	Oral Polio Vaccine
PHC	Primary Health Care
POO	Provincial Operations Officer
RDMS	Regional Director of Medical Services
ROO	Regional Operations Officer
TT	Tetanus Toxoid vaccine
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

ACKNOWLEDGEMENTS

The cost-effectiveness study in Middle Region could not have been successful without the efforts of Mr. Ahmed Ibrahim Babiker, the Chief Financial Officer of the EPI and of Mohieldeldin Hassan Elkarim, Regional Operations Officer, Middle Region.

The team would also like to thank all of the health workers, provincial operations officers and other health personnel who graciously accommodated the team and responded to all of our questions. The cooperation of the EPI personnel met throughout the region was wholehearted. Their hospitality and generosity made the data collection meetings productive.

EXECUTIVE SUMMARY

In March and April 1989, a cost and cost-effectiveness study of the Expanded Programme of Immunization (EPI) was undertaken in the Middle Region of the Republic of Sudan. The study was conducted in collaboration with the Government of Sudan, the EPI, UNICEF and USAID through the REACH Project. The overall objective of the cost-effectiveness study was to: 1) determine and compare the costs of delivering EPI services through mobile teams and fixed facility strategies; and 2) determine the cost of the program at different levels of the health system. A survey approach with questionnaires was used to collect data on inputs into the program as well as to document program outcomes. Questionnaires were developed for mobile teams, health facilities, District Operations Officers (DOO) and Regional Operations Officers (ROO). The cost-effectiveness study was conducted in tandem with a 30-cluster coverage survey, and used the location of the clusters for the coverage survey as a way of randomly selecting mobile teams and health facilities corresponding to the target population interviewed for the coverage survey. In this manner, program costs for 1988 corresponded with gains made in coverage during 1988.

This study estimated that it costs $17,738 (LS 78,934) per year on average to operate a mobile team in Middle Region, compared to $8,305 (LS 36,957) for health facility operations. Personnel and per diem costs accounted for the largest proportion of total cost for both mobile teams and health facilities. Equipment costs represented a large share of total cost for the mobile teams.

The cost per dose was lower for mobile teams ($1.00 or LS 4.45) than for health facilities ($3.62 or LS 16). This difference was due primarily to lower numbers of doses administered at the health facility level: 10 times less than mobile teams. The mobile teams also had a lower cost per fully immunized child (FIC) ($13 or LS 59) as compared to health facilities ($29 or LS 127) due to higher numbers of fully immunized children for the mobile teams.

Several factors were identified which influenced the cost and cost-effectiveness ratios of mobile teams and fixed facilities: specifically, the numbers and types of health workers, the density of the population, the proximity of the delivery site to district or regional headquarters, and the total volume of services delivered. Cost information was combined with operational data to arrive at performance and operational indicators for the teams and facilities. The number of doses administered per health worker per immunization day was 5.7 for facilities compared to 51 for mobile teams, suggesting that the mobile team strategy was more productive in this region.

The variations among mobile teams and facilities could be used in the future to identify a model of operation based on effective and efficient delivery of immunization services. The performance of the other delivery sites and districts could be measured and evaluated against this model. The variation shows that there is a large potential for improving the

effectiveness (outcomes) and for reducing the cost (efficiency) of the program in Middle Region.

Some measures which could be taken include:

1) Establish birth registers in facilities and for mobile teams in order to follow children through their immunization series. These registers could be based on the month in which the child was born in order to access information quickly on the immunization status of the child.

2) Some mobile teams operate with more than three personnel per team, which increases the cost of operating the teams without improving the productivity of the team by a commensurate amount. Efforts should be made to streamline the numbers of personnel involving in immunization routes.

3) Facilities and mobile teams in Middle Region have more equipment and supplies than teams in other regions presumably because of the proximity of Middle Region to central EPI headquarters. However, the increased supply of materials has increased the operating cost of each strategy without significantly increasing the output of the region. Efforts should be made to optimize the distribution of scarce material resources either within Middle Region or between regions in order to improve the overall program performance.

4) Other primary care activities should be integrated with routine EPI services provided by the mobile teams.

5) Record-keeping for the mobile teams and facilities could be improved if carbon copies of the monthly and annual reports are made and retained at the facility or mobile team office. This would provide the supervisors of immunization activities in these delivery strategies with valuable feedback and reference on immunization activity for health workers.

I. INTRODUCTION

In March-April 1989, the cost and cost-effectiveness study of the EPI was undertaken in four northern regions of the Sudan. The study was conducted by the EPI/Sudan in collaboration with UNICEF and USAID through the REACH Project.

This report covers the cost-effectiveness of the EPI in Middle Region. The organization and design of the EPI in Middle Region is described in Section II. The methodology for analyzing costs and effectiveness is described in detail in Section III. In brief, the approach was to use a combination of primary data collected using questionnaires during field visits by the team, and secondary data from EPI reports and other source documents (such as salary records and shipping reports) for information on the unit costs of supplies and equipment. Data on program effectiveness, such as number of doses administered, coverage levels, and days worked by health staff, were collected based on records and through interviews with health staff and administrators. The study results are presented in Section IV. Recommendations and conclusions are found in Section V. The study's findings indicate measures which can be taken to improve the efficiency and effectiveness of the EPI in Middle Region.

A. Purpose of the Cost-effectiveness Study

The EPI began in 1976 in Sudan and has continued to expand services and improve coverage levels through mobile teams and fixed facility strategies. A significant amount of resources (nearly $10 million) are being expended for the delivery of immunization services nationwide and support for the program comes from the Ministry of Health (MOH), District Councils, UNICEF, USAID, WHO, and non-governmental organizations (NGOs) in different regions. Until now, there has not been a complete analysis of the total annual cost of the program, nor have these costs been compared with program outcomes to determine the cost per FIC.

In October 1988, the MOH/EPI approved a study protocol for a cost and cost-effectiveness study of the national program to be conducted in collaboration with the REACH Project, USAID, and UNICEF. A key input into the cost-effectiveness study was the results from the national coverage survey conducted by the MOH in April 1989; and therefore, the timing of the cost-effectiveness study was planned to coincide with field data collection efforts of the coverage survey team.

The overall objectives of the cost and cost-effectiveness study in Sudan are to: 1) determine and compare the costs of delivering EPI services through mobile team and fixed facility strategies; 2) compare cost figures with the numbers of fully immunized children as determined by the coverage survey; and, 3) assess and propose recommendations for improving the efficiency of services delivery for both strategies and for improving program management of EPI resources.

B. Objectives of the Study in Middle Region

The purpose of this study is to document the total inputs into the regional EPI in Middle Region from the Government of Sudan and donor organizations, and to compare the cost of these inputs with the number of doses administered and the number of fully immunized children less than one year of age. Data from Middle Region will be compared with those from other regions to assess the variation in implementation of the EPI and the cost implications of different strategies (see Volume V: Summary Report). Because of the difficulties in allocating resources between districts and Health Areas, the Middle Region analysis focuses on a comparison between the health facility and mobile team strategies and does not include district and regional results.

Data from the cost-effectiveness study will be useful both for planning and management of the program. Cost information can be used to plan and budget future resource needs in the region for full and successful implementation of program objectives. In addition, this study generates a set of management data which shows the distribution of human and material resources among districts and compares this distribution with immunization activity. Management decisions can be made about how to allocate resources among districts in order to improve immunization coverage. A set of indicators of mobile team and health facility effectiveness has been developed and these can be used to manage and monitor each strategy.

Data provided by the cost-effectiveness study can be used to create a more efficient delivery program in order to achieve higher coverage levels and reduce the burden of immunizable diseases in Sudan.

II. ORGANIZATION OF THE EPI IN MIDDLE REGION

The Middle Region is one of the most densely population regions in the Sudan, with a population of 4.7 million including 188,000 children less than one year of age. Based on 1983 census survey data, 20 percent of the population lives in urban areas; 74 percent live in rural areas; and six percent are nomadic. The Middle Region borders National Capital Region in the north, the Eastern Region and Ethiopia in the east, Upper Nile Region in the south, and Kordofan in the west. Middle Region is Sudan's most productive region and enjoys a relatively advanced infrastructure.

A. Goals of the EPI

The EPI began in Middle Region in 1978 in the major cities of the region. By 1985, only four percent of the children under one year of age were fully immunized. In March of 1986, the present acceleration program was launched. The goals of the acceleration program were to make immunization available and to vaccinate 90 percent of children under one year of age against the six EPI

target diseases and to immunize 90 percent of pregnant women against tetanus toxoid by 1990.

B. Description of the Organization of the EPI

Administratively, the region is composed of three provinces: Gezira, White Nile, and Blue Nile which are divided into 21 districts and further subdivided into municipal and rural councils. The organization of the health system in Middle Region is slightly different than that of other regions included in the cost-effectiveness study.

1. Regional Level

The delivery of immunization services is provided and managed through several levels in the health system. At the Regional level, the ROO for the EPI is responsible for coordinating all regional EPI activities with those of the MOH and other NGOs in the region. The ROO is responsible for ensuring proper and timely distribution of material resources for the EPI by making requests to the MOH. The ROO also supervises EPI activities in the region by making regular tours to the provinces and districts to assess their success and know the constraints they face. On an annual basis, the ROO collects district plans of operation and formulates a Regional Plan, against which resources are disbursed from EPI Headquarters in Khartoum. Each month, the ROO collects district level monthly summary sheets of immunization activity and submits them, along with data on kilometers travelled for district vehicles to Headquarters. In addition, the ROO is responsible for financial reporting to Khartoum on a tri-monthly basis.

At the regional level the EPI is also supervised by the Regional Director of Medical Services (RDMS). He oversees the progress of the program and is directly responsible for financial management at the regional level.

2. Health Areas and District Level

There are eight deputy directors who are responsible for one Health Area each. This is an administrative unit used only by the MOH which is intermediate between the regional and district level. Each of the eight Health Areas listed below contain between two and five districts:

Middle Gezira, administered from Wad Medani
East Gezira, administered from Rufaa
North Gezira, administered from Kamleen
West Gezira, administered from Menagil
North Blue Nile, administered from Sennar
South Blue Nile, administered from Damazine
North White Nile, administered from Duem
South White Nile, administered from Kosti

A Health Area Operations Officer (HAOO) is responsible for the EPI in each Health Area. Each district (21 total) is supervised by a vaccinator from the smallpox campaign.

C. Strategies of the EPI

In urban areas, the primary strategy is to provide immunization services through static health facilities and through outreach services. The purpose of the mobile team is to reach the population groups living in remote areas which do not have access to other health services. A mobile team usually consists of a vehicle, a seven-day cold box, vaccines, disposable syringes, vaccinators, a driver, assistant driver, and sometimes a team leader. A mobile team covers several villages each month (one round), depending upon how far these villages are from each other and from the Health Area office.

Personnel in static EPI facilities are general health service workers who were given special training in vaccination. The mobile team and static health facilities maintain separate records of immunization activities.

Gezira University has begun work to integrate EPI and Control of Diarrheal Disease Program (CDD) activities in the region. This is being done with the cooperation of the Central MOH in Khartoum and the MOH in Middle Region.

D. Progress of the EPI in Middle Region

Coverage in 1986 rose from four to 25 percent of children fully immunized, while in 1987, 37 percent of children under one year of age received all required EPI vaccines. Table II.1 compares 1987 and 1988 coverage data based on reporting to the EPITrack system. Coverage of children less than one year of age is calculated based on the number of doses administered before the age of one and estimates of the target population calculated for the 1983 census. The target population in 1988 was 188,000 for children less than one and 236,122 for pregnant women.

TABLE II.1
COMPARISON OF COVERAGE RATES FOR CHILDREN LESS THAN ONE YEAR 1987-88
MIDDLE REGION
(percentages)

Antigen	Coverage 1987	Coverage 1988
BCG	76	83.6
DPT3/OPV3	51	70.4
Measles		51.3
Fully Immunized	37	59.7
TT2	18	28.8

E. Constraints to the Implementation of the EPI

Few constraints were noted as impeding the progress of the program in the region, which has achieved a high coverage rate. The demand for EPI staff in other countries, particularly the Arab oil countries, places a strain on the staffing patterns in the region. In addition, EPI vehicles are utilized in other departments, especially by medical staff who are not involved in the EPI.

III. METHODOLOGY

The methodology which was developed for the study was founded on providing the EPI with practical and relevant information in order that financial and economic information about the programme could be used for better planning and management in the future. The approach combined the use of operational data collected in the field by the study team, with cost data obtained both from the Districts and Regional Headquarters in Kordofan, and from the National Headquarters, UNICEF and other organizations in Khartoum. This chapter describes the data collected during field visits, the methods used for estimating EPI costs, the sampling process, and limitations of the methodology.

A. Questionnaires

The field data were collected using structured questionnaires, developed and field tested in Khartoum Region, which were designed to collect information on:

1) the number and types of personnel working on EPI at each level, and the hours per week spent on EPI;

2) the number and types of vehicles and equipment used in the last year for EPI, and how many of each type was not working at the time of the interview;

3) the number of supplies (syringes, needles, Road to Health cards, cold chain monitor cards, etc.) used in the programme;

4) the number of kilometers travelled for different immunization activities, such as mobile team rounds, publicity, meetings and replacement of stock; the mode of transport used in each case;

5) information on the type and quantity of fuel, oil and other lubricants used for the programme in the last year;

6) the number of doses of each antigen administered to children, by age (under and over one year of age) and dose, and to pregnant women (by dose);

7) the catchment population and the number of FIC;

8) the number of training courses and the number and type of staff trained during the last year;

9) the amount of local radio and television time for EPI publicity; and

10) the size and age of buildings used for EPI, and the percent of time for which this space was used by the programme.

The questionnaires were pretested in the National Capital Region with the help of the ROO and the DOO for Khartoum District. Through the pretest, it was determined that the reference period for number of doses, supplies and fuel should be the previous month (February 1989) instead of the previous year, because of the incompleteness of records and problems of recall.

B. Costing Methods

The methods used for calculating costs are those developed by Creese (1976) and revised by REACH (1988) and WHO (1988). The methodology of this study uses not only budgetary and price data, but also an analysis of the operations of the programme's delivery system.

Personnel costs were based on the number of hours spent working on EPI by different cadres of health staff. Hours worked per week on EPI was divided by the number of hours in a full-time week to estimate the number of full time equivalents (FTEs) in each staff category working on EPI. These estimates were multiplied by the monthly gross salary (including transport allowance, working allowance, housing, and social security) for each member of staff; if exact salary data were not available, the average for that person's cadre was used. Per diem costs were based on rates received in the field per month by health workers and administrative personnel. In some districts, the councils were paying additional benefits for overtime and travel allowance. Staff support, an additional payment from the EPI, was paid to some staff at Regional level. Average salaries for staff working on EPI in Darfur are shown in Appendix 4.

Vaccine costs were based on the number of vials of vaccine used during February 1989, multiplied by 12 to estimate annual doses consumed. Although there are seasonal variations in immunization activity, February is a typical month and it was believed that using this month as a reference period would not bias the projections. The approach of costing vaccine consumption rather than doses administered accounts for wastage, which is a real cost to the immunization programme. Stock data on doses issued (i.e., consumed) were taken from the monthly reports at district and regional levels. For mobile teams and health facilities stock data were not always available, and vaccine consumption was estimated by the staff being interviewed. The cost per vial for each antigen was estimated from UNICEF and MOH shipping reports of all vaccines received in 1988; since EPI National Headquarters receives vaccine shipments every quarter, the shipping reports for 1988 represented all vaccine needed for the Sudan in a 12-month period. Costs per vial were: BCG $0.760, DPT $0.732, OPV $0.678, measles vaccine $1.137, TT $0.199. International freight charges, which were another 14 percent in addition to the value of vaccine, have not been included in the costs per vial at regional level, but are included under transportation costs at National level. Details of all these vaccine costs are given in Appendix 4.

The cost of supplies also was estimated from the number of each item used during February 1989, multiplied by 12 to estimate annual use. The unit price of each item (e.g. 1 cc syringe, 2 cc syringe) was multiplied by the annual quantity of that item used, to obtain the total annual cost of supplies (see Appendix 4).

Transportation costs were estimated from the number of kilometers travelled in the last month (or if available, the last year), the number of kilometers travelled per gallon of fuel, and the price per gallon of fuel. If data on distances travelled by the mobile team were not available (e.g. the log book was out with the vehicle), the number of kilometers was estimated by tracing the team's routes to obtain kilometers per month then multiplying by the number of rounds per year, which varied between five and twelve. For transportation at district level, the kilometers travelled by each vehicle in the last year could usually be obtained. The DOOs were asked about the number of gallons of fuel, oil, and lubricants used each month and the price per gallon (or per can). There was some variation in prices between districts, reflecting the cost of transporting the goods to more remote areas. These

data were used to estimate the annual cost of fuels, engine oil and lubricants.

Maintenance and operation of vehicles could not be obtained from records of repairs undertaken, as damaged vehicles were sometimes shipped to the Regional or National Headquarters for repairs, or vehicles were mended with parts cannibalized from others. Thus maintenance costs were estimated using two sources. One was an analysis undertaken by the Cold Chain Section at National EPI Headquarters. The second was the total value of spare parts purchased in 1988, divided by the total number of vehicles in the fleet. This came to 23 percent of the annualized cost of the vehicle, excluding the cost of oils and lubricants. A separate study of vehicle maintenance costs in Niger estimated a figure of 24 percent, corroborating the methods used for the Sudan (see Appendix 4).

Capital investments for vehicles, buildings, and equipment last for periods longer than one year. The total purchase price is not allocated to the year of purchase, but is spread over the useful life of the equipment. Economists also adjust for the fact that money today is worth more than money in the future, and therefore the purchase price of a vehicle or equipment or the construction cost of a building is not spread evenly over its lifetime. An interest rate (r) is needed to make this adjustment. For this study, the official interest rate of 25 percent was used, representing the level of administrative charges levied on loans to Sudan from other Islamic countries.

This procedure for calculating the annualized value of capital investments gives an annual capital cost which is used in estimating the total annual cost of the programme. For Sudan, the useful life of capital equipment was determined in collaboration with EPI staff, and by using data from this study's inventories which showed the proportion of vehicles which were out of order. The use-life of vehicles is assumed to be five years; for large cold chain equipment it is five to 10 years, and two to eight years for cold boxes and vaccine carriers. Details of the purchase price of each type of vehicle and equipment, its use-life, and the annualized cost are given in Appendix 4. Costs are reported in U.S. dollars. An exchange rate of LS 4.45 was used to convert the purchase price of locally procured items into U.S. dollars. This rate of exchange was the average of the UN rate (LS 4.40) and the official rate in 1988 (LS 4.50).

Building costs were estimated by measuring the amount of space (square meters) used by the EPI, and collecting data on construction costs per square meter. If the space was not used all the time for EPI, a proportion of time for EPI was estimated (hours per week for EPI divided by full-time hours at that facility). Construction costs were amortized over the expected life of the building. Fired brick and cement buildings were assumed to have a 25 year use-life, sun-dried brick structures (usually self-help or cooperatives) were assumed to have a 10 year use-life, and grass structures were assumed to last for five years.

For each service delivery strategy (mobile teams and fixed facilities), cost per dose was calculated using the total annual cost divided by the number

of doses (all antigens, all ages) given per year. Mobile team and health facility records contained information on the numbers of doses administered per month. For the cost-effectiveness study, the reference month of February 1989 was selected to determine annual numbers of doses administered as well as the number of children fully immunized less than one year of age. The cost per FIC was the ratio between total cost of the EPI for childhood doses (total cost minus proportion of costs for tetanus toxoid to pregnant women) and the number of FIC.

Data were entered onto Lotus 1-2-3 spreadsheets; each cost category (e.g. personnel, vaccine, supplies, and transportation) had an individual worksheet and separate set-ups for calculating the line items within each category. The final cost figure for each category was imported into a summary table for each level or strategy. Results are shown in Section IV.

Limitations in the methodology which emerged during the analysis are discussed in Section III.E below.

C. Sample Selection

Because the cost-effectiveness study evaluated mobile team and facility strategies, several regions which had varying degrees of coverage and approaches to service delivery were surveyed in order to capture the range of experience found in Sudan. Middle Region was included because of its proximity to national EPI headquarters and access to immunization resources, as well as its higher population density and coverage rates.

In order to improve upon the methods of previous cost-effectiveness studies, this cost-effectiveness study aims to match the investments and resources used for the delivery of EPI services at different levels of the health system, with program outcomes as measured by the coverage survey. To do this, the study team sampled mobile teams and facilities from clusters which had been randomly selected on a population-proportional basis for the April 1989 coverage survey. It was believed that "following" the coverage survey would provide a random element in the selection process, though the final facilities and mobile teams surveyed depended in large part on logistic capabilities, security status, and whether or not a cluster was served by a team or facility.

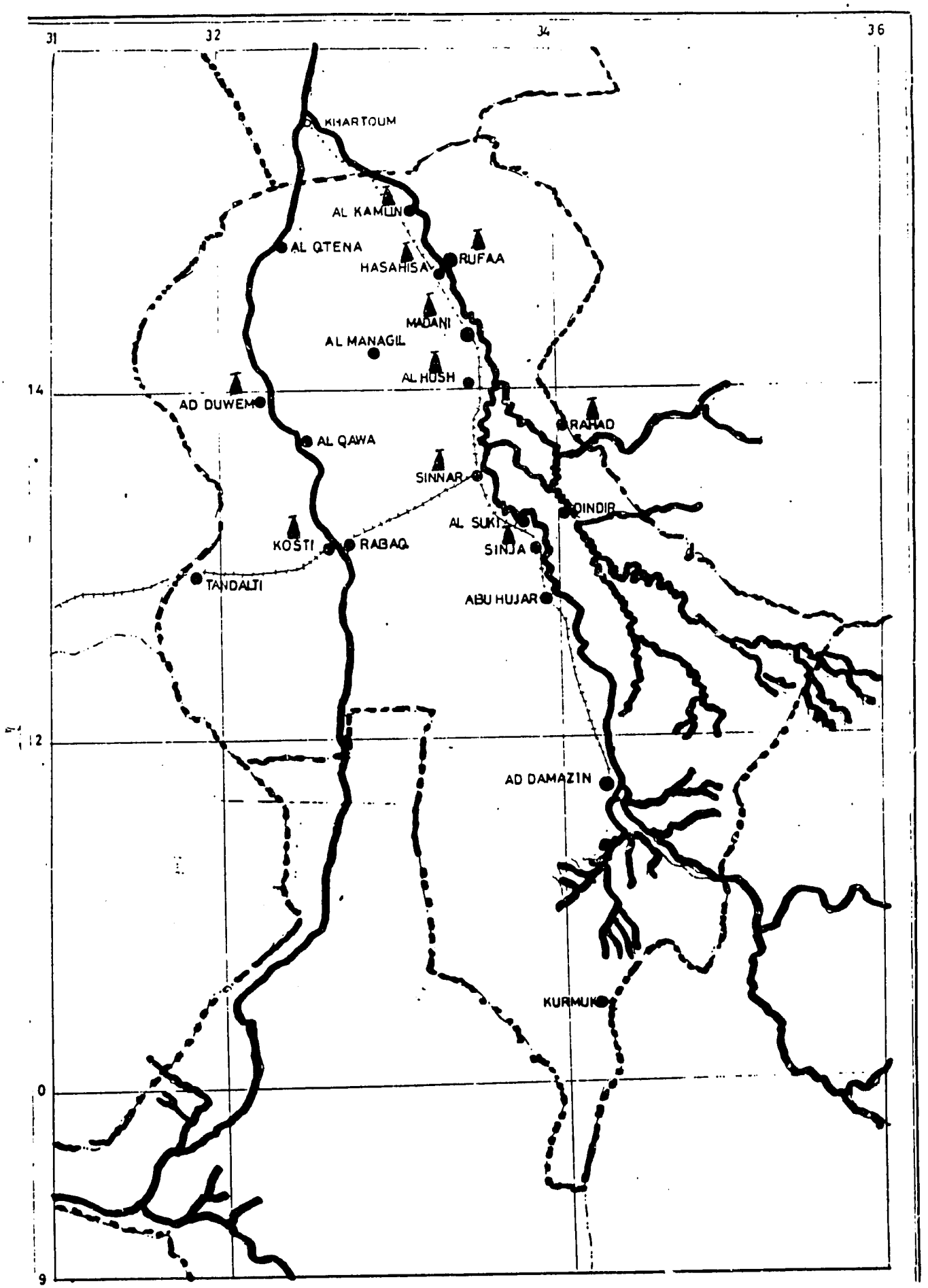
Each field team was encouraged to select sites on the following basis:

1) sample half of the districts within a region;

2) sample half of the mobile teams within the region; and

3) sample 15 facilities providing immunization services, with a balance between urban and rural.

MIDDLE REGION



▲ AREA OF CLUSTERS VISITED

Sampling half of the districts and mobile teams would provide enough representation of the range of performance, immunization activity, and use of resources possible within the Sudan. The selection of 15 facilities per region was based on previous facility costing studies. A sample of 50 facilities would be sufficient to test for significant differences among delivery sites.

At the delivery site level, whenever possible facilities or mobile teams operating near clusters visited by the coverage survey team were chosen. It was hoped that this would improve the comparability of costs and coverage figures. However, many clusters were selected which did not correspond directly with catchment areas of facilities. As a result, facilities had to be chosen based on logistical reasons (distance) and the existence of EPI services at these facilities.

D. Descriptive Statistics of Sample

Of the four regions surveyed, Middle Region is more densely population and is more developed than Darfur or Kordofan, though not nearly as developed as National Capital Region. Travel in the district is easier because of the number of improved roads which make easy access to the health facilities used for the EPI. As a result, questionnaires were completed for the full sample complement. Table III.1 illustrates the sample for Middle Region.

TABLE III.1
DELIVERY SITES SAMPLED FOR THE COST-EFFECTIVENESS STUDY IN MIDDLE REGION

Type of Questionnaire	Number	Urban	Rural	Match with Cluster (%)
Regional	1			
District	6			1 (14%)
Mobile Team	7			
Health Facility	15	10	5	9 (60%)
Total	29	10	5	10 (34%)

A total of 29 interviews were conducted at regional, district, mobile team and health facility level. Out of the 15 health facilities sampled, two-thirds were located in urban areas, and most of these were health centers and secondary hospitals. Sixty percent of the health facilities included in the sample matched with clusters selected randomly for the April coverage survey; the total matching between clusters and delivery sites in the Middle Region sample was 34 percent.

E. Limitations of the Methodology

During data collection and analysis phases of the study, several limitations were noted.

1. Questionnaires

First, the implementation of EPI was found to be more focused towards mobile team strategies than previously envisioned during the pre-test of the questionnaires in the National Capital Region. This resulted in a sampling of facilities which were drop-off points for mobile teams, and these did not fit the definition of fixed facilities (static with refrigeration equipment).

2. Reference Period

The analysis of costs and outcomes was based on a reference period of one month to improve the respondent's ability to recall information and to limit the amount of data which needed to be collected during an interview. It was believed at the start of the study that the month of February was an average month of activity for the EPI and therefore did not place a bias in the study results.

Second, it was discovered during field data collection that there had been shortages of syringes in some districts which affected the total level of immunization activity in the reference month of February. This would have resulted in an underestimation of activity for the district for the year (as February data were multiplied by 12). However, in some districts activity from other months may have been used instead of February because it was felt by DOOs that these months were more representative of activity. At regional level, the total level of immunization activity was taken from yearly records, rather than for February, to correct for variations in activity in the cost analysis.

3. Changes in Salary Payments

In July 1988, salary raises were given to health workers and administrators though the raises were not paid until September 1988. The level of pay raise was not uniform across categories of staff. To estimate the average annual salary of a particular category of staff, the average pay increase for that category was applied to the monthly base salary of each individual. The base salary figures were used during the first seven months of the year, and the new adjusted rates were used for the following five months.

4. Quality of Data

There was considerable variation in the quality of the records kept at district and provincial levels. Data on doses received and used during the month (as reported on monthly summary sheets) did not always tally with stock

remaining at the end of the month. In many cases, negative wastage rates were reported which shows that the worker or DOO is not clear about which figures should be included in the form. DPT and OPV doses given were considered to be the same in all cases and therefore there was not an active counting of OPV activity. Using one month as a reference period may have influenced calculation of negative wastage rates: supplies from a previous month were used during February. However, if the form is filled completely, this discrepancy would not have arisen.

5. Health Areas

For this region, the presence of health areas complicated data analysis, as resources are shared and the EPI is managed at both the district and health area levels. The sampling process had to be adjusted to reflect this system.

IV. RESULTS FOR MOBILE TEAMS AND FIXED FACILITIES

This section presents the results of the analysis for mobile teams and fixed facilities. Costs are calculated for eight categories of total cost: personnel (wages and benefits), per diem, vaccines, supplies, transportation, maintenance and operation of vehicles, and the annualized values of equipment and vehicles. Appendix 3 provides more detailed tables of the results and Appendix 4 provides data on the unit prices and wages used in the analysis.

A. Mobile Teams

1. Average Annual Cost

The average annual cost for the seven mobile teams in the sample was $17,738 (LS 78,934). Recurrent costs represented 69 percent of total cost, and capital costs were 31 percent of total cost. Personnel accounted for 22 percent of total cost, ranging from $3,031 (LS 13,488) per year for a team in the Blue Nile province to $4,692 (LS 20,879) for a team in the White Nile Province. Per diem costs were almost as high as personnel costs (salaries and benefits) at 20 percent of total annual cost. The annual value of equipment (e.g., cold boxes and tape recorders) represented 29 percent of total cost. Surprisingly, vaccine costs accounted for seven percent of total cost on average, ranging from $400 for a team in Blue Nile (LS 1,780) to $4,216 (LS 18,761) for a team in Eastern Gezira. Vaccine costs are indicative of the level of immunization activity for a team or the amount of vaccine wastage per team.

TABLE IV.1

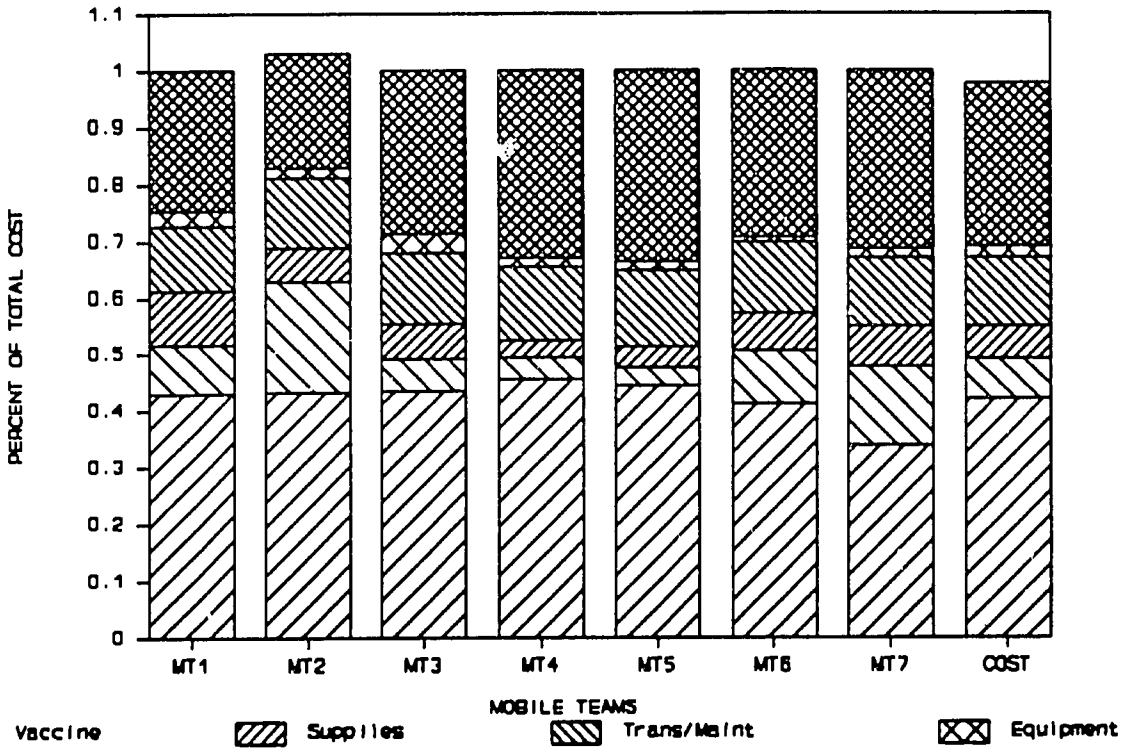
COST OF THE EPI FOR MOBILE TEAMS IN MIDDLE REGION

COST CATEGORY	TOTAL MT1	TOTAL MT2	TOTAL MT3	TOTAL MT4	TOTAL MT5	TOTAL MT6	TOTAL MT7	AVERAG COST
RECURRENT (in US $)								
Person-nel	3,862	4,692	3,862	3,080	3,031	4,692	3,279	3,785
Per Diem	3,681	4,706	2,681	2,872	2,656	4,706	3,937	3,606
Vaccines	1,544	4,216	844	518	400	2,136	2,951	1,381
Supplies	1,686	1,271	948	391	467	1,488	1,528	1,039
Transpor	744	762	627	437	465	883	647	652
Mainten-ance	1,251	1,251	1,251	1,251	1,251	1,941	1,941	1,448
TOTAL	12,768	16,899	10,213	8,550	8,270	15,845	14,283	12,404
CAPITAL (in US $)								
Equip.	466	429	515	217	228	221	300	339
Vehicles	4,315	4,315	4,315	4,315	4,315	6,693	6,693	4,994
TOTAL	4,781	4,744	4,830	4,532	4,543	6,914	6,993	5,334
TOTAL COST	17,550	21,643	15,043	13,082	12,813	22,759	21,277	17,738
Doses Admin.	24,048	20,664	20,856	12,221	6,444	23,556	46,695	22,069
Cost/ Dose ($)	0.73	1.05	0.72	1.07	1.99	0.97	0.46	1.00
% TT Doses	9.0	7.8	7.2	0.3	12.5	12.1	7.6	8.1
Total Child Cost ($)	15,970	19,955	13,960	13,042	11,212	20,006	19,660	16,258
Coverage (FIC)	2,196	1,248	942	1,023	948	2,424	915	1,385
Cost/ FIC ($)	7.27	15.99	14.82	12.75	11.83	8.25	21.50	13.20

NB: Total number of FIC from reported data for eadch mobile team in February, multiplied by the number of rounds made per year for annual FIC.

FIGURE IV.1

COST PROFILES: MOBILE TEAMS IN MIDDLE REGION



Several cost components were relatively constant across the seven mobile teams in the sample. For example, the annual value of vehicles and maintenance and operation of vehicles were similar for all teams. The variation in average annual cost is due to several factors:

1) The number of composition of the mobile team significantly influenced the total cost of the team.

2) The number of kilometers driven by the team and the unit cost of fuel influenced transportation costs.

3) Vaccine and supplies costs were directly linked to the level of immunization activity of the mobile team. Those teams with the greatest activity had the highest vaccine and supplies costs. Vaccine costs were also related to the wastage rates found for the mobile teams and these are reported in the next section.

4) The numbers of types of vaccination equipment. Some of the mobile teams were well stocked with cold chain equipment which increased their operating cost.

2. Number of Doses

The number of vaccinations administered by dose, antigen and age was collected from monthly records for February 1989. All figures reported here were based on EPI records as they were kept in the field. The total doses administered annually by the seven teams ranged from 6,444 to 46,695: a seven-fold difference. The average number of doses administered per month was 2,151. For some teams, there were more second and third doses of DPT and OPV administered than first doses, presumably because of efforts to reduce the drop-out rate.

TABLE IV.2
INDICATORS OF ACTIVITY FOR THE MOBILE TEAMS IN MIDDLE REGION

INDICATOR	AVERAGE	MINIMUM	MAXIMUM
Cost per Dose[1]	$1.00	$0.46	$1.99
Doses per Mobile Team per Day[2]	149	21	708
Doses per Staff per Day[3]	51	11	236
Doses per Site per Month[4]	62	14	152
Days per Round5	28	6	60
Returns to HQ per Round	9	3	33

[1] Total annual cost divided by total doses administered per year.
[2] Monthly doses administered by team divided by number of days per round.
[3] Monthly doses administered by team divided by number of staff (excluding drivers) divided by the number of days per round (month).
[4] Monthly doses administered by team divided by the number of sites visited.
5 Sixty days per round means that the team completed one round of sites every two months.

a) Cost per dose

For the seven mobile teams in the study, the average cost per dose administered was $1.00 (LS 4.45). The level of activity of the mobile teams influenced the range in the cost per dose from $0.49 (White Nile) to $1.99 (Blue Nile). Differences in the cost per dose are due almost entirely to the number of doses administered. Table IV.2 provides these results and other indicators of mobile team activity based on doses.

b) Doses per team and per health worker

Table IV.2 illustrates the wide range in level of activity by mobile team and per staff member (excluding drivers) among the seven mobile teams sampled in Middle Region. The average number of doses administered per team per day in the field was 149; whereas, the average number of doses administered per staff member (excluding driver) was 51. The mobile teams having the highest output per day were Western Nile and Eastern Gezira (236). The teams having the least output per health worker per day were located in South Gezira Health Area (27 doses).

These data could be interpreted in three principal ways. First, the number of eligible children and women for immunization is too low for some of the mobile team routes and this is why the output in some areas is low compared to others. Thus, the frequency and location of the mobile team routes should be redesigned to maximize the number of eligibles per day, while at the same time serving the remotest population groups. Second, the number of staff per team is too high to result in a high output per person and therefore the staffing patterns should be re-examined to lower cost and improve cost-effectiveness. Finally, the mobile team staff are not reaching enough children and could improve their productivity. Strategies to improve the motivation of the staff to seek out eligibles should be developed and the use of the loudspeakers improved.

c) Doses per site (subcenter)

Table IV.3 shows that for the sample of mobile teams, 627 different subcenters were used. Most of the subcenters were houses (52%), followed by dressing stations (19%), and primary health care units (15%). Only one of the mobile team sites routinely provided immunization in addition to mobile team activities.

The mobile team questionnaire also collected data on proportion of time spent by team workers during an immunization session in a village. On average, 52 percent of the total time was spent giving immunizations, 17 percent was spent travelling to the village, and nine percent was spent preparing the mobile team vehicle for departure to the village. In South Gezira Health Area, one of the teams spent 22 percent of their time administering ORT and providing health education as part of the efforts to integrate diarrheal disease control programs with the EPI (see Appendix 3).

The average number of doses administered at one mobile team site per month was 62. The range was 14 doses per site in South Gezira to 152 doses per site in Western Nile Health Area. These figures suggest that either the sites are too small to make continued use of mobile teams at monthly intervals financially worthwhile, or that not enough children and women are being reached during each session.

TABLE IV.3
SITES FOR MOBILE TEAM ACTIVITIES IN MIDDLE REGION

TYPE OF SITE	NUMBER	PERCENT
Health Center	17	2.7
Dispensary	65	10.5
Dressing Station	117	18.7
PHC Unit	96	15.4
Secondary Hospital	1	0.1
Houses	326	52.2
Schools	2	0.4
TOTAL	626	100.0

These data show that the cost per dose could be reduced by:

1) making sure that all eligibles, particularly those who are less than one year of age, come for immunization during the mobile team session in order to maximize the output of the team;

2) reducing the size of the mobile team staff to be more appropriate for immunization in villages with smaller target population sizes in order to optimize the productivity of each worker;

3) visiting larger villages in order to capture more eligibles at one time;

4) visiting villages less frequently in order to increase the number of eligibles at any one time; or

5) spending more time mobilizing the population effectively to come for sessions.

d) Kilometers per dose and days per round

Another indicator that measures the level of effective activity is the number of kilometers driven per dose administered. When the number of kilometers per dose is large, it may be a reflection of the dispersion of the population, or the vehicles are being used for other purposes than immunization. When the number of kilometers per dose is low, the team does not travel far to reach large numbers of children. For the sample of mobile teams, the average number of kilometers per dose was 1.6, with a range of 0.6 kilometers per dose in White Nile (team 7) to three kilometers per dose in Blue Nile (team 5). In general, these figures are much lower than those reported for mobile teams in Kordofan and Darfur, presumably because the population density in Middle Region is much higher. Urban mobile teams have low ratios between kilometers travelled and doses administered and do not represent the best use of scarce resources when an alternative strategy (fixed facility) is present.

The number of days per round is also an indication of the efficiency and effectiveness of mobile team operations. For Middle Region, the number of days per round (days required to visit are sites) averaged 28, but ranged from six to 60. The number of returns to headquarters during each round averaged nine and ranged from three to 33. These figures mean that the teams were away from district headquarters three days (28 days per round/nine returns per round). Each mobile team is equipped with a seven-day cold box, and therefore, there is a greater potential for the teams to streamline their routine patterns to maximize the number of sites visited per trip out of district headquarters.

3. Number of Fully Immunized Children and Cost per FIC

The number of fully immunized children less than one year of age was calculated for the mobile teams based on review of records in Middle Region. Data for the month of February were extrapolated for the year. These figures should be considered estimates and do not represent actual figures. For the sample, the average number of fully immunized children was 1,385. The highest and the lowest figures were reported for White Nile Province (2,424 versus 915 children).

The average cost per FIC was $13.20 and ranged from $21.50 in White Nile to $7.27 in Gezira. These figures reflect the range in immunization activity of the EPI among the mobile teams more than any other factor.

4. Drop-out Rates

Data from monthly reports were used to determine the drop out rates between doses for DPT, OPV and TT. Table IV.4 illustrates these results.

Negative drop-out rates imply that more subsequent doses were given. The highest drop-out rate for DPT1-DPT2 was found in Gezira; the highest for DPT2-DPT3 was in White Nile Province which also had the highest DPT1-DPT3 rate. Tetanus drop-out rates between the first and second doses reached 90

percent in Gezira. The drop-out rates for DPT1-DPT3 and TT1-TT2 for the six northern regions estimated from the coverage survey were consistently lower than from the reporting system.

TABLE IV.4
DROP-OUT RATES FOR MOBILE TEAMS
MIDDLE REGION
(percentages)

MOBILE TEAM	DPT1-DPT2 OPV1-OPV2	DPT2-DPT3 OPV2-OPV3	DPT1-DPT3 OPV1-OPV3	TT1-TT2
Gezira 1	-74	-24	29	77
Gezira 2	-15	5	17	90
Gezira 3	75	54	-86	44
Blue Nile 1	-37	-16	15	50
Blue Nile 2	29	18	-17	40
White Nile 1	51	78	55	59
White Nile 2	74	68	-23	64

5. Wastage

The data collected on doses administered also provided a means for analyzing wastage rates for individual antigens for each mobile team. Results shown in Table IV.5 show that there is no consistent pattern of wastage among the mobile teams or between antigens. Wastage was estimated from the monthly records of doses issued, doses administered and stock remaining at the end of the month. The following formula was used:

$$\text{Wastage} = \frac{\text{Doses of Vaccine Issued} + \text{Stock on Hand} - \text{Doses Administered}}{\text{Doses of Vaccine Issued}}$$

TABLE IV.5
VACCINE WASTAGE RATES FOR MIDDLE REGION
(selected mobile teams, in percentages)

ANTIGEN	GEZIRA 1	GEZIRA 2	WHITE NILE 1
BCG	---	66	52
DPT	11	86	18
OPV	11	88	38
MEASLES	31	52	60
TT	53	90	59

These data show the high rates of wastage for vaccines in the region, which have implications for the cost of the mobile team strategy. Wastage rates are influenced by the coverage level. At higher levels of coverage, higher rates of vaccine wastage are expected as the number of eligibles decreases. These high rates may in part be due to higher coverage levels in Middle Region. Wastage rates may be reduced if doses per vial of vaccine is also reduced from 20 to 10.

6. Summary of Mobile Teams

The analysis of the cost-effectiveness of seven mobile teams in Middle Region has highlighted several operational aspects which appear to affect the total cost and the performance of the teams. The matrix below can be used to characterize the mobile teams.

Most of the mobile teams in Middle Region fall into the category of high cost and high immunization activity. Only one mobile team (Blue Nile Province) could be considered the most cost-effective of the sample (low cost and high activity); in addition, one team may be characterized as the least cost-effective of the sample (White Nile Province): high cost and low activity. The relative positions in this matrix were determined based on median cost and activity figures for the sample and do not represent absolute characterizations of cost-effectiveness. However, a mobile team which has relatively low annual costs and high annual activity is using resources in a more efficient and effective manner than teams which have lower activity or higher costs.

TABLE IV.6
CLASSIFICATION OF MOBILE TEAMS IN MIDDLE REGION BY COST/FIC

OUTCOMES	HIGH COST	LOW COST
HIGH	Gezira Gezira White Nile	Blue Nile
LOW	White Nile	Gezira Blue Nile

This characterization of teams according to level of cost and outcome can be used by the ROO and HAOOs to identify which mobile team:

1) is the most cost-effective and why in order to develop a standard of performance and use of resources; and

2) could become more cost-effective by increasing the outcome or by decreasing their costs and to plan how to move the mobile teams within these cells away from the high cost/low outcome scenario.

The following matrix highlights some of the characteristics of mobile teams which can be helpful in explaining the relative variation in cost and effectiveness.

TABLE IV.7
CHARACTERISTICS OF MOBILE TEAMS

	HIGH COST	LOW COST
HIGH OUT-COME	CASE 1 Days out per month is high, with many returns to HQ Many centers, far apart, with large target pop. Kilometers (& fuel) high Large team spends time on identifying eligibles, following up drop outs	CASE 2 Days out per month is high, with few returns to HQ Few centers with large target population (high density) Short distances Small team of health workers High utilization by eligibles Community enumerates and follows up
LOW OUT-COME	CASE 3 Size of team exceeds that needed for the workload Many returns to HQ for restocking/rotating staff Many centers, far apart, with small target populations Low utilization Ineffective follow-up	CASE 4 Small team of health workers Few days per round Few rounds per year (low per diem) Few centers are visited, with small target populations Low percentage of eligibles is contacted; no follow-up

B. Health Facilities

1. Average Annual Cost

The cost-effectiveness study team surveyed 15 facilities, most of which were urban health centers. The total annual cost of providing immunization services through facilities is found in Table IV.8. Only 13 out of the 15 facilities sampled had sufficient data on immunization activity (doses and fully immunized children).

The average annual cost of facilities for the sample was $8,305 or LS 36,957. Total cost ranged from $3,972 (LS 17,675) in an EPI unit in Kosti to $14,163 (LS 63,025) for a secondary hospital in Eastern Gezira. It appears from the data that that scale of operation of health services (EPI-specific unit to a hospital) influences the cost of providing immunization services. Large facilities have higher costs and vice versa.

Recurrent costs accounted for 69 percent of the total cost, and the annual values of vehicles, equipment, and buildings accounted for the balance of 31 percent of the total. Personnel and per diem costs were the highest cost category at 49 percent, followed by buildings (21%) and vaccines (15%). Transportation, equipment and vehicles costs were not significant cost elements of fixed facility EPI operations.

The three-fold difference between the annual operating cost of EPI in facilities in Middle Region is accounted for largely by variations in personnel and vaccine costs. Dibagha Health Center in South and Middle Gezira had the highest personnel costs at $7,508 (LS 33,411) which had larger numbers of vaccinators and other personnel involved in the immunization program compared to Meilig in Northern Gezira and Singa in Sennar ($1,451 each).

Vaccine costs showed the most striking variations: from a low of $119 in a health facility in South and Middle Gezira to a 31-fold increase of $3,666 (LS 16,314) in a Sennar facility. Variation in vaccine costs was due to differences in the level of output and high wastage rates for vaccines.

Building costs varied from $5 in a facility in White Nile Province to $5,333 (LS 23,732) in Housh health center in Eastern Gezira. The range in estimates is largely due to variations in the size of the area used for immunization as well as the unit price per square meter for construction. Many of the facilities in the Middle Region sample were constructed within the past 15 years.

In two facilities in White Nile Province, recurrent costs amounted to nearly 100 percent of the total cost of providing immunization services. This is primarily a result of the very small annualized value of buildings and equipment.

TABLE IV.8
COMPARISON OF HEALTH FACILITY COSTS FOR MIDDLE REGION

COST CATEGORY	AVERAGE	PERCENT	MINIMUM	PERCENT	MAXIMUM	PERCENT
RECURRENT COST						
1. Personnel	$3,777	45.5%	$1,451	89.4%	$7,508	34.5%
2. Vaccines	$1,219	14.7%	$119	7.3%	$3,712	17.1%
3. Supplies	$727	8.8%	$41	2.5%	$2,421	11.1%
4. Transport	$48	0.6%	$0	0.0%	$333	1.5%
TOTAL RECURRENT	$5,770	69.5%	$1,611	99.3%	$13,974	64.2%
CAPITAL COSTS						
1. Equipment	$570	6.9%	$6	0.4%	$1,900	8.7%
2. Vehicles	$226	2.7%	$0	0.0%	$544	2.5%
3. Buildings	$1,739	20.9%	$5	0.3%	$5,333	24.5%
TOTAL CAPITAL	$2,535	30.5%	$11	0.7%	$7,777	35.8%
TOTAL COST	$8,305	100.0%	$1,622	100.0%	$21,751	100.0%
NUMBER OF DOSES	2,296		36		8,724	
COST PER DOSE	$3.62		$1.62		$275.57	
PERCENT TT DOSES	11.6%		0.0%		59.1%	
TOTAL CHILD COST	$8,076		$1,625		12,804	
NUMBER FIC	961		60		2,748	
COST/FIC	$28.57		$2.90		$112.93	

2. Number of Doses

The average annual number of doses administered for the sample of facilities was 2,296. Vaccination activity varied by facility from 36 in a health center in South and Middle Gezira to 8,736 doses per year in a secondary hospital in Eastern Gezira. The hospital administered 243 times more immunizations than the health center, demonstrating the range in immunization activity in the region. One facility in White Nile Province administered more tetanus toxoid immunizations than immunizations to children (52% of doses were TT doses).

a) Cost per dose

The average cost per dose for 13 health facilities in the sample was $3.62 (LS 16). The cost per dose ranged from $1.62 (LS 7) in Eastern Gezira to $276 (LS 1,228) in South and Middle Gezira. The facility with the lowest figure had among the highest levels of immunization activity, though the total annual cost was approximately average for the sample. The extremely high figure for South and Middle Gezira may be explained by low immunization activity for the month of February. If this facility is removed from the sample, the highest ratio of cost per dose is found in White Nile Province at $37 or LS 165. This facility had one of the lowest total costs, but low immunization activity made it the least cost-effective in terms of cost per dose for the sample. This facility is kept in the analysis because it may represent others experiencing similar levels of immunization activity.

b) Doses per day

Table IV.9 provides data on the number of doses administered per full-time equivalent (FTE) health staff, per day and per hour for the sample of 15 facilities. The Republic of Sudan has a policy to immunize children on demand at health facilities. On average, six child immunizations are given during each immunization session day, which translates to less than one dose administered per hour. The range of doses per day was between 0.13 and 30 per immunization session, and the range in doses per hour was between 0.02 and nearly 4. The number of doses per hour represents a 200-fold difference in immunization activity among health facilities. This difference could be due to differences in sizes of the target population as well as differences in levels of staff motivation to immunize. The highest figures were for an urban hospital in Eastern Gezira, though not every urban center had high levels of productivity for health workers.

The number of doses per staff per month averaged 75 in the sample, with a range between less than one (South and Middle Gezira health center) and 600 (Eastern Gezira hospital). For the sample, less than one-half dose per hour per FTE was administered, suggesting significant underutilization of health workers for the immunization program. The range was from almost none to three doses per FTE per hour. Administering three doses per hour does not constitute full time labor, raising issues about the underemployment of health workers or low utilization rates of facilities by the population. Low productivity and low utilization contribute to high program costs and decreased efficiency. This analysis suggests that the cost-effectiveness of facilities could be improved significantly if the productivity of health

workers improved or there was greater use of health facilities for immunization by the target population.

These activity indicators suggest that the cost per dose could be reduced by increasing the level of immunization activity per session, either by improving publicity for the session or by undertaking outreach activities in urban areas. Immunization staff should be able to administer at least 24 doses per hour, if the session is scheduled correctly and the population has been informed. These data also suggest that there should be different standards for urban and rural facilities, with more emphasis on increasing the volume of services provided in urban areas where the population density is greatest and the transmission of disease more likely.

TABLE IV.9
INDICATORS OF MONTHLY ACTIVITY AT HEALTH FACILITIES IN MIDDLE REGION

INDICATOR	AVERAGE	MINIMUM	MAXIMUM
Cost/Dose	$3.62	$1.62	$275.57
Doses/Day	5.66	0.13	30.29
Doses/Hour	0.74	0.02	3.79
Doses/FTE/Month	74.74	0.66	600.83
Doses/FTE/Hour	0.45	0.02	3.13

Cost/dose = total annual cost divided by total doses administered per year.
Doses/day = total doses administered per month divided by the number of immunization days per week.
Doses/hour = total doses administered per day divided by the number of hours for each immunization clinic.
Doses/FTE/month = total doses administered per month divided by the number of FTE in the facility.
Doses/FTE/day = total doses administered per month divided by the number of immunization days per month.

3. Number Fully Immunized Children

The number of fully immunized children is not routinely recorded on monthly immunization records. To collect this information, the survey team reviewed the registers of the facility to determine how many children less than one received their last required dose during February, 1989. This figure was multiplied by 12 to estimate the annual number of children fully immunized and should only be considered an estimate.

For the sample, the average number of FIC less than one year of age was 961 per year. This figure ranged from 60 in South and Middle Gezira Province to 2,748 in Eastern Gezira. The number of FIC may have been influenced by the density of the population, or by the type of strategy used at the facility to follow-up immunizations of children rather than providing solely on demand.

Using the number of FIC, it was estimated that the average cost per FIC in the sample was $28.57 (LS 127). This figure ranged from a low of $2.90 in Eastern Gezira (in the same facility with the highest number of FIC) to a high of $112.93 (LS 503) in the facility with the lowest numbers of FIC. This results illustrate how important the level of activity is in calculating the overall cost-effectiveness of health facilities, as the numerator (costs) did not appear to play a major role in determining the final outcome of the analysis.

4. Drop-out Rate

The drop-out rate between different doses of vaccine are illustrated in Table IV.10. From these data it is difficult to draw conclusions about patterns in drop-out rates. Drop-out rates between DPT1 and DPT3 were highest for a health facility in Eastern Gezira (48%); whereas, the rate for TT drop-out is highest for a facility in Sennar. Negative wastage rates are either a reflection of poor record-keeping or immunization efforts to reduce drop-outs. These data provide some evidence that facility immunization performance could be improved by reducing drop-out rates from their present levels of about 40 percent.

TABLE IV. 10
COMPARISON OF DROP-OUT RATES FOR SELECTED HEALTH FACILITIES IN MIDDLE REGION
(percentages)

HEALTH FACILITY:	DPTP1-DPTP2	DPT2-DPT3	DPT1-DPT3	TT1-TT2
HF1: S/M Gezira	nil	42	42	41
HF2: S/M Gezira	-20	-50	-25	10
HF4: E. Gezira	-16	24	35	20
HF5: E. Gezira	14	55	48	--
HF10: Sennar	40	65	41	92
HF11: Sennar	3	21	18	13
HF13: Kosti	40	50	40	55
HF15: El Duem	79	82	14	-9

5. Wastage Rate

Wastage rates were based on the number of vials consumed during a month, compared with the number of vials stocked and left on hand. These data were only available for some of the facilities, as the other facilities did not keep stock records or accurate information (i.e., some facilities reported negative wastage). The wastage rates for selected facilities are shown in Table IV.11.

TABLE IV.11
COMPARISON OF WASTAGE RATES AMONG SELECTED FACILITIES IN MIDDLE REGION
(percentages)

ANTIGEN	HF 2	HF4	HF6	HF9	HF12	HF14
BCG		30	60	85	60	75
DPT	67	9	10	74	50	86
OPV	67	9	10	74	9	88
Measles	75	40	68	80	46	89
TT	50	41	75	80	17	71

This table shows a wide variation in wastage rates for five antigens for selected health facilities in the sample. In general, the rates are high (above 50%), although the wastage rates for DPT are below 10 percent in some facilities. If wastage is reduced, there are potential cost savings which can improve the efficiency of the health facility strategy.

6. Summary of Results for the Fixed Facility Strategy

The most cost-effective health facilities were those which had the highest level of immunization activity. Table IV.12 organizes the facilities into the cost and outcome matrix shown earlier for mobile teams. Those in Cell 2 are the most cost-effective. Those in Cell 3 are the least cost-effective. Those in Cell 1 can be made more cost-effective by decreasing the facility cost at the same or greater level of outcome. Those in Cell 4 could be improved by increasing their level of outcome without increasing the cost of providing services at the same rate.

TABLE IV.12
CLASSIFICATION OF HEALTH FACILITIES IN MIDDLE REGION BY COST/FIC

OUTCOMES	HIGH COST	LOW COST
HIGH	1 HF4: Eastern Gezira HF7: Eastern Gezira HF8: N. Gezira HF15:El Duem	2 HF6: Eastern Gezira HF11: Sennar HF12: Sennar
LOW	3 HF1: S/M Gezira HF2: S/M Gezira HF5: Eastern Gezira	4 HF3: S/M Gezira HF9: N. Gezira HF10: Sennar HF13: Kosti HF14: W. Nile

This classification scheme suggests that the health facilities in Middle Region (at least the ones in the sample) are evenly spread between low and high costs and immunization activity. The most cost-effective facilities are those with low costs and high outcomes; whereas, the least cost-effective facilities are those with high costs and low outcomes. The relative position in this matrix was based on median figures for the sample, and therefore, it is difficult to judge which facilities are cost-effective or not efficient in absolute terms. However, it is clear from the analysis that those facilities which recorded a higher level of outcomes tended to be more cost-effective than others. In qualitative terms, Table IV.13 illustrates some of the factors contributing to the relative placement of facilities in the matrix.

TABLE IV.13
HEALTH FACILITIES: INDICATORS OF COST AND EFFECTIVENESS

	HIGH COST	LOW COST
	CASE 1	CASE 2
HIGH OUT-	Resupply uses EPI vehicle Large staff spends time on enumeration & follow-up of defaulters EPI sessions occupy a large space Many sessions held, well attended	Minimal equipment Small staff Few sessions per week High utilization, follow-up done by community
	CASE 3	CASE 4
LOW OUT-COME	Resupply with EPI vehicle Large staff, low utilization, low activity EPI occupies a large space Many sessions held, poorly attended Time spent on social mobilization is not effective	Minimal Equipment Low utilization by target group, low activity Passive approach to follow-up of drop outs Small staff

C. Comparison of Alternative Strategies

Table IV.14 compares the two strategies by annual cost, cost per dose, and cost per FIC less than one year of age. This table shows that the mobile teams had a higher average annual cost by 53 percent over fixed facilities; number of doses and number of fully immunized children were also higher on average for the mobile teams by 90 and 30 percent, respectively. The cost per dose for mobile teams was lower by 262 percent than for health facilities, presumably because of the large differences in annual numbers of doses administered. The cost per FIC was less for mobile teams which suggests that this strategy is more effective in completing a child's immunization series than the fixed facilities. The data also suggest that fixed facility activity could be greatly improved.

TABLE IV.14
COMPARISON OF ANNUAL COSTS BY STRATEGY

INDICATOR	MOBILE TEAMS	FIXED FACILITIES	DIFFERENCE
Annual Cost	$17,738	$8,305	53%
Number of Doses	22,069	2,296	90%
Number of FIC	1,385	961	30%
Cost per Dose	$1.00	$3.62	-262%
Cost per FIC	$13.20	$28.57	-116%

Fixed facilities and mobile teams should be serving different population groups and as such, they do not represent direct alternatives to each other. However, in urban areas, it is clear that mobile teams are providing immunization services which may be provided at less cost by health facilities, thereby increasing the effectiveness of the facility strategy. Facilities could increase their cost-effectiveness by increasing the volume of services they provide during an immunization session. Mobile teams could decrease their costs by restricting the size of the villages they visit or by decreasing the frequency of the visits to smaller villages in order to increase the number of eligibles at any particular point in time.

V. CONCLUSIONS AND RECOMMENDATIONS

The analysis from Middle Region focused on comparisons between the mobile team and fixed facility strategies. These strategies cannot be considered direct alternatives as they are designed to serve different population groups: mobile teams serve remote areas not easily accessed by health facilities and EPI services based in facilities are designed to accommodate the urban and populated areas of the region. However, the analysis shows that the immunization activity per health worker per day in health facilities (six) lies much below that for mobile teams (51), which may be due to: 1) low productivity of health workers in facilities; 2) overlapping between the mobile team strategy and facility strategy resulting in smaller target population groups for the facilities; and 3) lack of a systematic method for following children through their entire immunization series in facilities. Facility activities tended to be more haphazard, rather than concerted.

On the other hand, the annual cost of facility services is nearly one-half that for the mobile teams in Middle Region. Costs could be reduced for both strategies by reducing wastage rates for vaccines, reducing drop-out rates, and by integrating immunization services with other primary care services in the mobile team strategy.

The study team also recommends the following measures be undertaken:

1) Establish birth registers in facilities and for mobile teams in order to follow children through their immunization series. These registers could be based on the month in which the child was born in order to access information quickly on the immunization status of the child.

2) Some mobile teams operate with more than three people per team which increases the cost of operation without improving the productivity of the team by a commensurate amount. Efforts should be made to streamline the numbers of personnel necessary to delivery immunization services through this strategy, and redirect the remaining workers to other activities at headquarters level, such as cold chain maintenance, record-keeping or other activities.

3) Facilities and mobile teams in Middle Region have more equipment and supplies than teams in other regions presumably because of the proximity of Middle Region to central EPI headquarters. However, the increased supply of materials has increased the operating cost of each strategy without significantly increasing the output of the region. Efforts should be made to optimize the distribution of scarce material resources either within Middle Region or between regions in order to improve the program performance overall.

4) Other primary care activities should be integrated with routine EPI services provided by the mobile teams.

5) Record-keeping for the mobile teams and facilities could be improved if carbon copies of the monthly and annual reports are made and retained at the facility or mobile team office. This would provide the supervisors of immunization activities in these delivery strategies with valuable feedback and reference on immunization activity for health workers.

APPENDIXES

APPENDIX 1	ITINERARY OF FIELD ACTIVITIES IN MIDDLE REGION
APPENDIX 2	PERSONS CONTACTED
APPENDIX 3	SUMMARY TABLES
APPENDIX 4	BACKGROUND TABLES

APPENDIX 1

ITINERARY OF FIELD ACTIVITIES IN MIDDLE REGION

This survey team had responsibility for Middle Region. The team was comprised of Ahmed Ibrahim Babiker, Driver Abdullah Elsheik, and Team Leader Michael Enright. The team left Khartoum on Saturday, March 11 and travelled to Wad Medani, the location of the Regional Operations Office for the EPI. The Regional Area Operations Officers were gathered for a monthly meeting and they were briefed about the purpose and goals of the cost-effectiveness study, as described in the body of this report. With the assistance of El Rasheed Mohammed, the Assistant Regional Area Operations Officer, the following sites were selected for the survey in Middle Region. Data collection continued until March 20, when the team returned to Khartoum.

APPENDIX 2

PERSONS CONTACTED

Gezira Province

Mohieleldin Hassan Elkarim, Regional Operations Officer

Kamil Elfadil Eljack, Health Area Operations Officer,
South and Middle Gezira Area

Khalafalla Mohamed Ahmed, Health Area Operations Officer, Eastern Gezira Area

Kamil Abdullah, Health Area Operations Officer, Northern Gezira Area

Atta Ahmed Abdullah, Health Area Operations Officer, Sennar Area

Blue Nile Province

Tahra Ishag Ibraihaim, Health Area Operations Officer, Kosti Area

White Nile Province

Mohieldin Osman Ahmed, Health Area Operations Officer,
North White Nile Area (El Duem)

APPENDIX 3
SUMMARY TABLES

Appendix 3.1

ESTIMATION OF TRAVEL COST AND OTHER INDICATORS FOR THE MOBILE TEAMS
MIDDLE REGION

MOBILE TEAM/ INDICATOR	MT1 S. GEZIRA	MT2 S. GEZIRA	MT3 N GEZIRA	MT4 B. NILE	MT5 B. NILE	MT6 W. NILE	MT7 W. NILE	AVERAGE	STANDARD DEVIATION
Kms travelled per round	2,760	2,828	5,323	500	1,594	2,600	2,400	2,572	1,360
Scheduled rounds per year	12	12	6	12	12	12	11	11	2
Actual rounds last year	12	12	6	11	12	12	11	11	2
Percent scheduled to actual rounds	100.0%	100.0%	100.0%	91.7%	100.0%	100.0%	100.0%	98.8%	2.9%
Kms travelled per year	33,126	33,936	31,938	18,000	19,128	31,200	28,800	28,018	6,171
Sites visited/ro.	65	38	60	30	38	20	28	40	15
No. returns/ro.	4	33	8	3	4	3		9	11
Days per round	30	33	60	21	25	24	6	28	15
Staff per team	3	4	3	2	2	3	3	3	1
Doses given/mo	2,004	1,722	3,476	1,111	537	1,963	4,245	2,151	1,199
Doses given/yr	24,048	20,664	20,856	12,221	6,444	23,556	46,695	22,069	11,693
No. FIC/mo.	183	104	157	93	79	202	42	123	54
No. FIC/yr	2,196	1,248	942	1,023	948	2,424	462	1,320	665
Population served <1 year	1,939	238	0	4,553	800	5,286	1,964	2,111	1,919
Days/site	0.5	0.9	1.0	0.7	0.7	1.2	0.2	0.73	0.31
Kms/Dose	1.4	1.6		1.5	3.0	1.3	0.6	1.57	0.70
Kms/FIC	15	27	34	18	20	13	62	27	16
Doses/site/mo.	31	45	58	37	14	98	152	62	44
Doses/FIC/mo.	11	17	22	12	7	10	101	26	31
Doses/day	67	52	58	53	21	82	708	149	229
Doses/person/day	22	13	19	26	11	27	236	51	76
FIC/day	6.10	3.15	2.62	4.43	3.16	8.42	7.00	4.98	2.06
Kms/day	92.00	85.70	88.72	23.81	63.76	108.33	400.00	123	115.77
Dose/population	12.40	86.82		2.68	8.05	4.46	23.78	23	29
FIC/population	1.13	5.24		0.22	1.19	0.46	0.24	1.41	2

APPENDIX 3.2

COST-EFFECTIVENESS OF THE MOBILE TEAMS IN MIDDLE REGION

COST CATEGORY	SOUTH GEZIRA TOTAL MT1	SOUTH GEZIRA TOTAL MT2	NORTH GEZIRA TOTAL MT3	BLUE NILE TOTAL MT4	BLUE NILE TOTAL MT5	WHITE NILE TOTAL MT6	WHITE NILE TOTAL MT7	AVERAGE COST
RECURRENT COST								
1. Personnel	$3,862	$4,692	$3,862	$3,080	$3,031	$4,692	$3,279	$3,785
2. Per diem	$3,681	$4,706	$2,681	$2,872	$2,656	$4,706	$3,937	$3,606
2. Vaccines	$1,544	$4,216	$844	$518	$400	$2,136	$2,951	$1,381
3. Supplies	$1,686	$1,271	$948	$391	$467	$1,488	$1,528	$1,039
4. Transportation	$744	$762	$627	$437	$465	$883	$647	$652
5. Maintenance/Op. of Vehicles	$1,251	$1,251	$1,251	$1,251	$1,251	$1,941	$1,941	$1,448
TOTAL RECURRENT	$12,769	$16,899	$10,213	$8,550	$8,270	$15,845	$14,283	$12,404
CAPITAL COSTS								
1. Equipment	$466	$429	$515	$217	$228	$221	$300	$339
2. Vehicles	$4,315	$4,315	$4,315	$4,315	$4,315	$6,693	$6,693	$4,994
TOTAL CAPITAL	$4,781	$4,744	$4,830	$4,532	$4,543	$6,914	$6,993	$5,334
TOTAL COST	$17,550	$21,643	$15,043	$13,082	$12,813	$22,759	$21,277	$17,738
DOSES ADMINISTERED	24,048	20,664	20,856	12,221	6,444	23,556	46,695	22,069
COST/DOSE	$0.73	$1.05	$0.72	$1.07	$1.99	$0.97	$0.46	$1.00
PERCENT TT DOSES	9.0%	7.8%	7.2%	0.3%	12.5%	12.1%	7.6%	8.1%
TOTAL CHILD COST	$15,970	$19,955	$13,960	$13,042	$11,212	$20,006	$19,660	$16,258
COVERAGE (FIC)	2,196	1,248	942	1,023	948	2,424	915	1,385
COST/FIC	$7.27	$15.99	$14.82	$12.75	$11.83	$8.25	$21.50	$13.20

NB: Total number of FIC from reported data for each mobile team in February, multiplied by the number of rounds made per year for annual FIC.

APPENDIX 3.3

COMPARISON OF EPI COSTS AMONG HEALTH FACILITIES: MIDDLE REGION

COST CATEGORY	HF1	HF2	HF3	HF4	HF5	HF6	HF7	HF8
RECURRENT COST								
1. Personnel	$7,508	$6,923	$3,118	$2,990	$2,799	$3,177	$5,915	$4,866
2. Vaccines	$423	$119	$715	$3,666	$231	$1,553	$2,001	$380
3. Supplies	$374	$41	$890	$1,973	$286	$750	$1,268	$580
4. Transport	$0	$29	$11[illegible]	$333	$8	$216	$0	$85
TOTAL RECURRENT	$8,305	$7,112	$4,733	$8,961	$3,324	$5,696	$9,185	$5,911
CAPITAL COSTS								
1. Equipment	$298	$273	$1,900	$268	$1,304	$1,077	$354	$125
2. Vehicles	$0	$403	$403	$403	$544	$403	$0	$403
3. Buildings	$2,133	$2,133	$1,166	$4,532	$5,333	$1,280	$1,933	$2,133
TOTAL CAPITAL	$2,431	$2,809	$3,468	$5,202	$7,181	$2,760	$2,287	$2,661
TOTAL COST	$10,736	$9,920	$8,201	$14,163	$10,505	$8,456	$11,472	$8,572
NUMBER OF DOSES	804	36		8,724	732	2,832	4,476	2,628
COST PER DOSE	$13.35	$275.57		$1.62	$14.35	$2.99	$2.56	$3.26
PERCENT TT DOSES	17.3%	31.7%	0.0%	9.6%	12.4%	5.6%	5.2%	11.2%
TOTAL CHILD COST	$8,879	$6,776	$8,201	$12,804	$9,202	$7,982	$10,876	$7,612
NUMBER FIC	408	60	216	1,728	192	2,748		2,568
COST/FIC	$21.76	$112.93	$37.97	$7.41	$47.93	$2.90		$2.96

Appendix 3.3

(Continued)

COST CATEGORY	HF9	HF10	HF11	HF12	HF13	HF14	HF15
RECURRENT COST							
1. Personnel	$1,451	$2,902	$4,405	$1,451	$2,902	$2,902	$3,341
2. Vaccines	$1,220	$217	$1,532	$521	$900	$1,094	$3,712
3. Supplies	$412	$382	$547	$428	$152	$399	$2,421
4. Transport	$7	$0	$0	$29	$0	$0	$0
TOTAL RECURRENT	$3,090	$3,501	$6,483	$2,429	$3,954	$4,396	$9,473
CAPITAL COSTS							
1. Equipment	$845	$6	$271	$1,801	$7	$7	$8
2. Vehicles	$0	$283	$283	$272	$0	$0	$0
3. Buildings	$525	$1,289	$3,364	$111	$11	$5	$139
TOTAL CAPITAL	$1,370	$1,578	$3,918	$2,184	$18	$12	$147
TOTAL COST	$4,460	$5,079	$10,402	$4,613	$3,972	$4,408	$9,620
NUMBER OF DOSES	564	204		828	108	324	1,056
COST PER DOSE	$7.91	$24.90		$5.57	$36.78	$13.61	$9.11
PERCENT TT DOSES	10.5%	12.7%	20.9%	15.1%	59.1%	11.3%	13.0%
TOTAL CHILD COST	$3,992	$4,434	$8,228	$3,916	$1,625	$3,910	$8,370
NUMBER FIC	396	336	2,208	588	168	240	984
COST/FIC	$10.08	$13.20	$3.73	$6.66	$9.67	$16.29	$8.51

Appendix 3.4

COMPARISON OF HEALTH FACILITIES IN MIDDLE REGION (PERCENT OF TOTAL COST)

COST CATEGORY	COST CATEGORY	HF1	HF2	HF3	HF4	HF5	HF6	HF7	HF8
RECURRENT COST	RECURRENT COST								
1. Personnel	1. Personnel	69.9%	69.8%	38.0%	21.1%	26.6%	37.6%	51.6%	56.8%
2. Vaccines	2. Vaccines	3.9%	1.2%	8.7%	25.9%	2.2%	18.4%	17.4%	4.4%
3. Supplies	3. Supplies	3.5%	0.4%	10.8%	13.9%	2.7%	8.9%	11.1%	6.8%
4. Transport	4. Transport	0.0%	0.3%	0.1%	2.4%	0.1%	2.6%	0.0%	1.0%
TOTAL RECURRENT	TOTAL RECURRENT	77.4%	71.7%	57.7%	63.3%	31.6%	67.4%	80.1%	69.0%
CAPITAL COSTS	CAPITAL COSTS								
1. Equipment	1. Equipment	2.8%	2.7%	23.2%	1.9%	12.4%	12.7%	3.1%	1.5%
2. Vehicles	2. Vehicles	0.0%	4.1%	4.9%	2.8%	5.2%	4.8%	0.0%	4.7%
3. Buildings	3. Buildings	19.9%	21.5%	14.2%	32.0%	50.[illegible]	15.1%	16.9%	24.9%
TOTAL CAPITAL	TOTAL CAPITAL	22.6%	28.3%	42.3%	36.7%	68.4%	32.6%	19.9%	31.0%
TOTAL COST	TOTAL COST	$10,736	$9,920	$8,201	$14,163	$10,505	$8,456	$11,472	$8,572

Appendix 3.4

(Continued)

COST CATEGORY	HF9	HF10	HF11	HF12	HF13	HF14	HF15
RECURRENT COST							
1. Personnel	32.5%	57.1%	42.3%	31.5%	73.1%	65.8%	34.7%
2. Vaccines	27.3%	4.3%	14.7%	11.3%	22.7%	24.8%	38.6%
3. Supplies	9.2%	7.5%	5.3%	9.3%	3.8%	9.1%	25.2%
4. Transport	0.2%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%
TOTAL RECURRENT	69.3%	68.9%	62.3%	52.7%	99.5%	99.7%	98.5%
CAPITAL COSTS							
1. Equipment	18.9%	0.1%	2.6%	39.0%	0.2%	0.2%	0.1%
2. Vehicles	0.0%	5.6%	2.7%	5.9%	0 0%	0.0%	0.0%
3. Buildings	11.8%	25.4%	32.3%	2.4%	0.3%	0.1%	1.4%
TOTAL CAPITAL	30.7%	31.1%	37.7%	47.3%	0.5%	0.3%	1.5%
TOTAL COST	$4,460	$5,079	$10,402	$4,613	$3,972	$4,408	$9,620

APPENDIX 4
BACKGROUND TABLES

TABLE 4.1

PERSONNEL COST ESTIMATES: MIDDLE REGION

CATEGORY	BASE/MO	TRANSPORT	HOUSING	SUB/MO	TRAVEL OVERTIME	TOTAL/ MONTH	TOTAL/ YEAR	TOTAL $$
DS of Health	1746.32	0	0	1746.32	0	1746.32	20,956	$4,709
R.D.C.	430.76	0	100	530.76	0	530.76	6,369	$1,431
Asst R.D.C.	354	25	90	469	0	469	5,628	$1,265
H.A.D.C.	354.5	25	90	469.5	0	469.5	5,634	$1,266
Medical Officer	686.6	50	250	986.6	0	986.6	11,839	$2,660
Medical Assistant	344.5	25	90	459.5	0	459.5	5,514	$1,239
Health Visitor				0		0	0	$0
Vaccinator	222.5	25	60	307.5	230.62	538.12	6,457	$1,451
Supervisor	222.5	25	60	307.5	230.62	538.12	6,457	$1,451
Nurse	98.25	25	45	168.25	75.68	243.93	2,927	$658
Statistician	293	25	90	408	0	408	4,896	$1,100
Supply Officer	134.5	25	45	204.5	0	204.5	2,454	$551
Accountant	573	25	80	678	0	678	8,136	$1,828
Typist	166	25	45	236	0	236	2,832	$636
Guards	75	25	45	145	45	190	2,280	$512
Generator Oprs	75	25	45	145	45	190	2,280	$512
Cold Chain Tech	129.75	25	45	199.75	45	244.75	2,937	$660
D.D.C.	585	50	0	635	0	635	7,620	$1,712

APPENDIX 4.2

COSTS OF VACCINE

The vaccine in the Sudan's EPI is procured through UNICEF. The amount spent on vaccine was determined from the UNICEF shipping reports; all invoices raised in 1988 were included in the cost of vaccine for that year. A total of 21 shipping reports were used in this analysis.

The shipping reports show the antigen, its value, and the cost of freight, in US dollars. The supporting documents from the manufacturer show how many vials of the vaccine were dispatched, cost per vial, and any special discounts (e.g. 0.3% discount for WHO testing). These supporting documents were needed in order to separate out the cost of individual antigens, since one-third of the shipping reports were a combined invoice for two different antigens. These are shown in Table 4.2a.

For each antigen, an average cost per vial and an average cost per dose was calculated. These figures were then used in the spreadsheets containing data on stock movements and doses administered, to calculate the cost of vaccine administered, and the cost of vaccine used (i.e. including the cost of wastage).

There was a complication in choosing the average costs for BCG: the first two shipments were 10-dose vials which worked out to cost almost three times more per dose than the 20-dose vials. Since all of the 10-dose BCG had already been used, the cost of BCG in 20-dose vials was used in this analysis.

Freight charges from the manufacturers to Khartoum have not been included in the calculation of the cost of vaccine at the levels of mobile team, health facility, district or region. The cost of international freight was 14% of the value of the vaccine itself.

For Kordofan Region, the annual cost of vaccine estimated by multiplying February 1989 data by 12 was $55,880 (see Table 4.2b). As a check upon whether this figure accurately represented annual consumption in Kordofan, the region's monthly reports of doses issued to Districts in 1988 were analysed; records were available in Central EPI files for 7 months. The annual cost of vaccine estimated from these data was $54, 831, which is within 2% of the figure used in this report. However, data on doses issued from Central HQ to the Regional HQ in 1988 produce a higher cost figure ($62,339). This was calculated from information in the report on Sudan's EPI Cold Chain (1988) pp.3-4. The variations in these cost estimates may be caused by seasonal differences in activity in the Region.

APPENDIX 4.2 Table 4.2a COST OF VACCINE AND FREIGHT, FROM SHIPPING REPORTS

TYPE OF VACCINE	RECEIVED AT CC STORES DOSES	DATE LOGGED	VIALS	DATE OF UNICEF SHIPPING REPORT	VALUE US $	COST PER VIAL	COST PER DOSE	AVERAGE COST PER DOSE	FREIGHT US $	0=One vaccine, one invoice 1=1st vaccine on combined invoice 2=2nd vaccine on combined invoice	
BCG	600000	21-Jan-88	60,000	11-Mar-88	$46,200	$0.770	$0.077		$10,330	0 $0.77/vial	10 doses
BCG	600000	07-Mar-88	60,000	15-Mar-88	$71,596	$1.193	$0.119		$8,578	0 Y152/vial,less 0.3%	10 doses
BCG	800000	30-Jun-88	40,000	07-Jul-88	$29,110	$0.728	$0.036		$3,394	0 £0.425/vial	20 doses
BCG			20,000	18-Jul-88	$20,400	$1.020	$0.051	$0.012 Min	$4,035	0 Y133/vial	"
BCG	200000	19-Jul-88	10,000	07-Sep-88	$2,451	$0.245	$0.012	$0.119 Max	$2,253	0	"
BCG	600000	01-Sep-88	30,000	28-Sep-88	$21,537	$0.718	$0.036		$4,788	2 a UK £ BCG @ £0.425	"
BCG	400000	14-Dec-88	20,000	22-Dec-88	$21,738	$1.087	$0.054		$4,849	0	"
	3200000		3,600,000								
				Avg 10-dose BCG		$0.982 per vial		$0.098 per dose for 10-dose vial			
				Avg 20-dose BCG		$0.760 per vial		$0.038 per dose for 20-dose vial			
DPT	1000000	26-Jan-88	50,000	22-Feb-88	$35,659	$0.713	$0.036		$5,695	1 b Swiss Francs	20 doses
DPT	1000000	28-May-88	50,000	20-Jun-88	$34,074	$0.681	$0.034		$5,152	0	"
DPT	500000	12-Jul-88	25,000	04-Aug-88	$14,935	$0.597	$0.030		$2,762	0	"
DPT	500000	19-Jul-88	25,000	18-Jul-88	$24,823	$0.993	$0.050		$2,955	0	"
DPT	1000000	20-Dec-88	50,000	03-Jan-89	$33,735	$0.675	$0.034		$13,301	0	"
	4000000		4,000,000					$0.037 Avg per dose			
				Avg 20-dose DPT		$0.732 per vial					
Polio	1250000	19-Feb-88	62,500	11-Mar-88	$24,375	$0.390	$0.020		$3,200	1 c YugoDinars	20 doses
Polio	1000000	13-Mar-88	62,500	19-Apr-88	$46,842	$0.749	$0.037		$10,293	1 d Ital.Lire	"
Polio	1310000	02-Aug-88	62,500	26-Sep-88	$48,077	$0.769	$0.038		$5,812	1 e Ital.Lire	"
Polio	600000	11-Dec-88	30,000	12-Oct-88	$24,158	$0.805	$0.040		$1,740	0	"
	4160000		4,350,000					$0.034 Avg per dose			
				Avg 20-dose OPV		$0.678 per vial					
Measles	500000	27-Jan-88	50,000	22-Feb-88	$70,796	$1.416	$0.142		$6,569	0	10 doses
Measles	625000	12-Mar-88	50,000	19-Apr-88	$60,778	$1.216	$0.122		$10,293	2 d Ital.Lire	"
Measles	500000	02-Aug-88	50,000	26-Sep-88	$62,381	$1.248	$0.125		$5,812	2 e Ital.Lire	"
Measles	125000	01-Sep-88	12,500	28-Sep-88	$8,515	$0.681	$0.068		$4,788	1 a UK £ (Vaccine-BCG)	"
Measles	375000	20-Dec-88	37,500	19-Jan-89	$42,188	$1.125	$0.113		$6,164	0	"
	2125000		2,000,000					$0.114 Avg per dose			
				Avg 10-dose Msls		$1.137 per vial					
TT	400000	19-Feb-88	20,000	11-Mar-88	$4,200	$0.210	$0.011		$3,200	1 c YugoDinars	20 doses
TT	400000	19-Apr-88	20,000	29-May-88	$3,877	$0.194	$0.010		$1,018	2 f YugoDinars	"
TT	400000	13-Jul-88	20,000	25-Aug-88	$3,877	$0.194	$0.010		$1,062	1 g YugoDinars	"
	1200000		1,200,000					$0.010 Avg per dose			
				Avg 20-dose TT		$0.199 per vial					
DT	40000	26-Jan-88	2,000	22-Feb-88	$1,256	$0.628	$0.031		$5,695	2 b Swiss Francs	20 doses
DT	40000	19-Apr-88	2,000	29-May-88	$2,453	$1.227	$0.061		$1,018	2 f YugoDinars	"
DT	40000	13-Jul-88	2,000	25-Aug-88	$2,453	$1.227	$0.061		$1,062	2 g YugoDinars	"
DT	40000	03-Sep-88	2,000	19-Oct-88	$730	$0.365	$0.018		$138	0	"
	160000		160,000					$0.043 Avg per dose			
				Avg 20-dose DT		$0.862 per vial					

TOTAL EXPENDITURE 1988 Vaccine $763,214 Freight $106,870 (106870/763214)= 14%

To cover the cost of international freight, ADD 14% of the cost of the vaccine.

TABLE 4.3

COMPARISON BETWEEN MAINTENANCE ESTIMATES
BY ANALYSIS OF EXPENDITURES AND HYPOTHETICAL CASES

EXPENDITURE DATA	PRICE	ANNUAL COST	MAIN COST	% PRICE	% COST
Toyota DC	$11,604	$4,314.91	$398.16	3.4%	9.2%
Toyota 8C	$10,649	$3,959.80	$398.16	3.7%	10.1%
Landcruiser	$18,000	$6,693.24	$398.16	2.2%	5.9%
Motorcycle	$1,000	$423.44	$303.96	30.4%	71.8%
Panda	$6,728	$2,501.83	$1,449.67	21.5%	57.9%
Average				12.3%	31.0%
HYPOTHETICAL CASE	**PRICE**	**ANNUAL COST**	**MAIN COST**	**% PRICE**	**% COST**
Toyota DC	$11,604	$4,314.91	$1,049.21	9.0%	24.3%
Toyota 8C	$10,649	$3,959.80	$1,049.21	9.9%	26.5%
Landcruiser	$18,000	$6,693.24	$1,049.21	5.8%	15.7%
Panda	$6,728	$2,501.83	$1,049.21	15.6%	41.9%
Average				10.1%	27.1%
AVERAGE MAINT/YEAR				11.2%	29.0%

TABLE 4.4

TRAINING COST PER PERSON

REGION	EXPENDITURE	NUMBER TRAINED	COST/ PERSON LS	COST/ PERSON $
DARFUR	71,955	1072	67	$15
KORDOFAN	72,218	1065	68	$15
MIDDLE	38,619	578	67	$15
NATIONAL CAPITAL	25,264	503	50	$11
AVERAGE	52,014	805	63	$14
EPI BUDGET	732,259	10,004	73	$16

Kordofan estimates based on 1988 allocation for training and numbers of participants in six districts adjusted for 10 districts. Other regional estimates based on weighted average of the number of participants at district level plus the number of participants at regional level.

TABLE 4.5

EQUIPMENT, VEHICLES AND SUPPLIES PRICES

		@IF(H7>0,H	25		3.984888
1	Toyota Hilux Double cab	$11,604.00	5	$4,314.91	2.689280
1.1	Toyota Hilux Single cab	$10,649.00	5	$3,959.80	2.689280
2	Land Cruiser Pickup Diesel	$12,601.50	5	$4,685.83	2.689280
2.1	Land Cruiser Saloon	$15,000.00	5	$5,577.70	2.689280
2.2	Land Cruiser	$18,000.00	5	$6,693.24	2.689280
3	Motorcycle 70cc	$951.00	4	$402.69	2.361600
3.1	Motorcycle 80cc	$1,000.00	4	$423.44	2.361600
3.2	Motorcycle Three-Wheeler	$1,244.56	4	$527.00	2.361600
3.3	Motorcycle 125 cc	$1,100.00	4	$465.79	2.361600
4	Bicycles	$203.67	2	$141.44	1.440000
5	Panda car	$8,728.11	5	$2,501.83	2.689280
6	Air conditioner	$800.00	5	$223.11	2.689280
7	Solar refrigerator BP	$4,000.00	10	$1,120.29	3.570503
7.1	Solar refrigerator (Italy)	$5,136.00	10	$1,438.45	3.570503
8	RCW42 EK	$920.00	10	$257.67	3.570503
9	TFW 791	$700.00	10	$196.05	3.570503
10	TCW 1151	$1,295.00	5	$481.54	2.689280
10.1	Admiral refrigerator	$1,011.24	10	$283.22	3.570503
10.2	ColdAir refrigerator	$788.52	10	$220.28	3.570503
10.3	Electrolux refrigerator	$1,115.00	10	$312.28	3.570503
10.4	Philips Tropical fridge	$600.00	5	$223.11	2.689280
10.5	Sibir refrigerator 82325	$900.00	5	$334.66	2.689280
10.6	Step-in Refrigerator +3Deg	$4,000.00	15	$1,036.47	3.859263
10.7	Walk-in Refrigerator +4Deg	$8,245.80	15	$2,136.83	3.859263
12	Admiral freezer	$1,573.03	10	$440.56	3.570503
12.1	Electrolux Chest freezer	$420.00	10	$117.63	3.570503
12.2	Vestfrost HF201 T Freezer	$182.00	10	$50.97	3.570503
12.3	?Chest freezer (Sussex)	$600.00	10	$168.04	3.570503
12.5	Ice-pack Freezer Asko Oy	$1,618.92	10	$452.85	3.570503
12.5	Walk-in Freezer -20 Deg	$9,469.47	10	$2,652.14	3.570503
13	Vaccine Carrier 1.7 lts	$14.60	3	$7.48	1.952000
14	Vaccine carrier 3504/38	$12.00	3	$6.15	1.952000
15	Vaccine Carrier 0.3 lts	$9.00	2	$6.25	1.440000
16	Ice packs for Model II	$0.40	3	$0.20	1.952000
16.1	Ice packs w/vial holes	$0.38	3	$0.19	1.952000
16.2	Thermos ice-packs (box)	$77.00	3	$39.45	1.952000
17	Dial Thermometer (probe)	$62.85	10	$17.60	3.570503
17.1	Recording Thermometer	$723.68	10	$202.68	3.570503
17.2	Digital thermometer	$218.09	10	$61.08	3.570503
18	Round Thermometer w/hook	$1.00	5	$0.37	2.689280
19	Cold Box 20 litres	$340.00	8	$102.14	3.328911
20	Cold Box 8.5 ltr Model 2	$96.50	5	$35.88	2.689280
21	RCW 25 (911 1501.01)	$299.00	8	$89.82	3.328911
21.1	Coleman Cold Box (E4/06)**	$72.00	2	$50.00	1.440000
22	Generator 4.5KVA	$1,300.00	5	$483.40	2.689280
22.1	Generator 15 KVA	$7,000.00	5	$2,602.93	2.689280
22.2	Generator 12.5 KVA	$3,400.00	5	$1,264.28	2.689280
22.3	Generator portable 0.5 KVA	$900.00	5	$334.66	2.689280
22.4	Generator, portable	$900.00	5	$334.66	2.689280
22.5	Generator 40 KVA	$7,043.00	5	$2,618.92	2.689280
22.5	Generator 4.5 KVA	$1,300.00	5	$483.40	2.689280
22.6	Generator 60 KVA	$7,043.00	5	$2,618.92	2.689280
23	Voltage Regulator(brown)	$264.00	5	$98.17	2.689280
23.1	Voltage Regulator(orange)	$264.00	2	$183.33	1.440000

TABLE 4.5 (cont.)

EQUIPMENT, VEHICLES AND SUPPLIES PRICES

23.2	Voltage Regulator (red)	$264.00	5	$98.17	2.689280
23.3	Voltage Regulator	$264.00	5	$98.17	2.689280
23.4	Transformer (Step-down) for	$750.00	5	$278.89	2.689280
24	Alarm system	$0.00	10		3.570503
25	Public Address (Mobile)	$146.00	5	$54.29	2.689280
25.1	Public Address (Fixed) TOA	$446.00	5	$165.84	2.689280
26	Megaphone -	$50.00	5	$18.59	2.689280
27	Tape recorder/Cassette	$47.00	2	$32.64	1.440000
28	Weighing scale	$200.00	10	$56.01	3.570503
29	Slide projector Hanimex	$117.30	2	$81.48	1.440000
30	Chair, metal frame	$40.45	5	$15.04	2.689280
31	Chair, wooden	$33.71	8	$10.13	3.328911
32	Table, wooden	$70.00	10	$19.61	3.570503
32.1	Small table/stool	$15.73	10	$4.41	3.570503
33	Desk with drawers, metal	$247.19	10	$69.23	3.570503
34	Shelves (4 stacked layers)	$107.87	10	$30.21	3.570503
35	Filing cabinet, 4-drawer	$178.00	5	$66.19	2.689280
36	Cupboard	$247.19	5	$91.92	2.689280
37	Duplicator Gestetner 4130	$683.00	5	$253.97	2.689280
38	Typewriter Arabic	$450.00	10	$126.03	3.570503
39	Typewriter English	$320.00	10	$89.62	3.570503
40	Oxyacetylene Gun & Hose	$250.00	5	$92.96	2.689280
41	Tank for Oxygen/Acetyline	$0.00	10	$0.00	3.570503
42	Regulator for tank	$0.00	10	$0.00	3.570503
43	Freon tank	$0.00	10	$0.00	3.570503
44	1 cc disposable syringe	$0.05			
45	2 cc disposable syringe	$0.03			
46	Vaccine monitor card	$2.73			
47	Registration book	$3.51			
48	Road to Health Cards	$0.05			
49	Cotton (packets)	$0.25			
50	Freezewatch indicator	$0.90			
51	Vaccine packing tape	$2.20			
52	Strip thermometer (E6/11)	$1.00			
53	Ice Pack Indicator (E6/13)	$0.18			
54	Cassettes	$1.40			
55	Dry cell batteries	$0.51			
56	Dry cell batteries	$0.82			