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Health & Demographic Surveillance System Profile

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Health & Demographic Surveillance System Profile: Farafenni Health and Demographic Surveillance System in The Gambia

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Abstract

The Farafenni Health and Demographic Surveillance System (Farafenni HDSS) is located 170 km from the coast in a rural area of The Gambia, north of the River Gambia. It was set up in 1981 by the UK Medical Research Council Laboratories to generate demographic and health information required for the evaluation of a village-based, primary health care programme in 40 villages. Regular updates of demographic events and residency status have subsequently been conducted every 4 months. The surveillance area was extended in 2002 to include Farafenni Town and surrounding villages to support randomized, controlled trials. With over three decades of prospective surveillance, and through specific scientific investigations, the platform (population $\approx$ 50 000) has generated data on: morbidity and mortality due to malaria in children and during pregnancy; non-communicable disease among adults; reproductive health; and levels and trends in childhood and maternal mortality. Other information routinely collected includes causes of death through verbal autopsy, and household socioeconomic indicators. The current portfolio of the platform includes tracking Millennium Development Goal 4 (MDG4) attainments in rural Gambia and cause-of-death determination.

Key Messages

- The Farafenni HDSS platform supports a range of biomedical investigations in addition to the routine measurement of demographic and population-based health indicators.
- It is among the oldest demographic surveillance sites in the world and can provide valuable information on progress of The Gambia towards meeting the Millennium Development Goals (MDGs) in The Gambia.
- Great potentials exist for further collaborative research initiatives in specific areas, which will maximize the utilization of Farafenni HDSS data.

Why was the Farafenni HDSS set up?

In 1978, the Government of The Gambia adopted primary health care (PHC) as the basis for its national health policy and rolled out a community-based health delivery system. An important component of this initiative was a village-based PHC programme. Each village with a population of 400 or more identified a village health worker (VHW) and a traditional birth attendant (TBA) for training.[1] Because of the absence of vital registration in the rural areas, the UK Medical Research Council Laboratories, The Gambia (now MRC Unit, The Gambia), was asked in 1981 by the Government of The Gambia to undertake a systematic evaluation of the impact of the PHC programme on morbidity and mortality. It was decided that the Farafenni area, where the MRC had just established a field site and where health care depended primarily on village-level services, would be an appropriate place to undertake this study. To generate the necessary demographic and health information required for this evaluation, the Farafenni Health and Demographic Surveillance System (Farafenni HDSS) was established in October 1981.

What does it cover now?

Surveillance in the Farafenni HDSS has been uninterrupted since 1981 except for a 13-month period between February 2008 and March 2009. The platform is currently jointly managed by the MRC Unit and the Armed Forces Provisional Ruling Council (AFPRC) General Hospital in Farafenni, with its main objectives being to measure levels and trends in under-5 mortality and to monitor progress towards attainment of Millennium Development Goal 4 (MDG4), i.e. to reduce under-five mortality by two-thirds between 1990 and 2015. In addition, the HDSS determines cause-of-death structure in the general population through verbal autopsy (VA) for establishing the changing epidemiology of communicable and non-communicable diseases in this rural area.

Where is the HDSS area?

The Farafenni HDSS is located between latitudes 13° and 14°N and longitudes 15° and 16°W, extending 32 km to the east and 22 km to the west of Farafenni (Figure 1). Farafenni town (2012 population ≈ 25 000) is situated in the North Bank Region of The Gambia and is 170 km inland from the capital, Banjul. The HDSS was initially made up of two clusters of villages and hamlets to the east and west of Farafenni town. Communities within a 10 km radius were excluded because the initial task of the platform was to assist in an evaluation of the impact of the village-based PHC programme on child and maternal morbidity and mortality,[2–4] with a particular focus on the role of malaria.[5–8] The surveillance area was expanded in July 2002 to include Farafenni town and its satellite villages. This new segment was designated the urban demographic surveillance area (DSA) despite the satellite villages being very similar to the rural ones, distinguishing it from the initial surrounding clusters of rural villages (Figure 1).

The surveillance area has a sub-Sahelian climate, with a single rainy season from June to October. Most malaria transmission, which has been decreasing in recent years,[9] occurs during September to December. The average annual rainfall in Farafenni for the period 1989 to 2008was 735 mm. The vegetation is dry savannah with scattered trees, but in the rainy season, grasses and bushes grow rapidly. Villages are poor with very low cash incomes. The gross national income per capita for the country was estimated at US$635 in 2011, a mean biased by income in urban areas. About 45% of the resident population of the DSA earn less than US$150 per year.[10]

The health care delivery system consists of 16 PHC posts and five dispensaries operated by VHWs under the supervision of community health nurses (CHNs), one health centre and a regional hospital. The CHNs serve the rural communities and supervise the volunteer VHWs and TBAs, who form the base of the PHC programme. The Farafenni health centre provides mainly reproductive and child health services. The AFPRC General Hospital, commissioned in 1999, is a 250-bed facility with paediatric, obstetric, gynaecological, medical, surgical, dental and ophthalmic units. It also has a laboratory with basic facilities for haematological, biochemical and parasitological investigations. The town has a few private dispensaries and pharmacies.

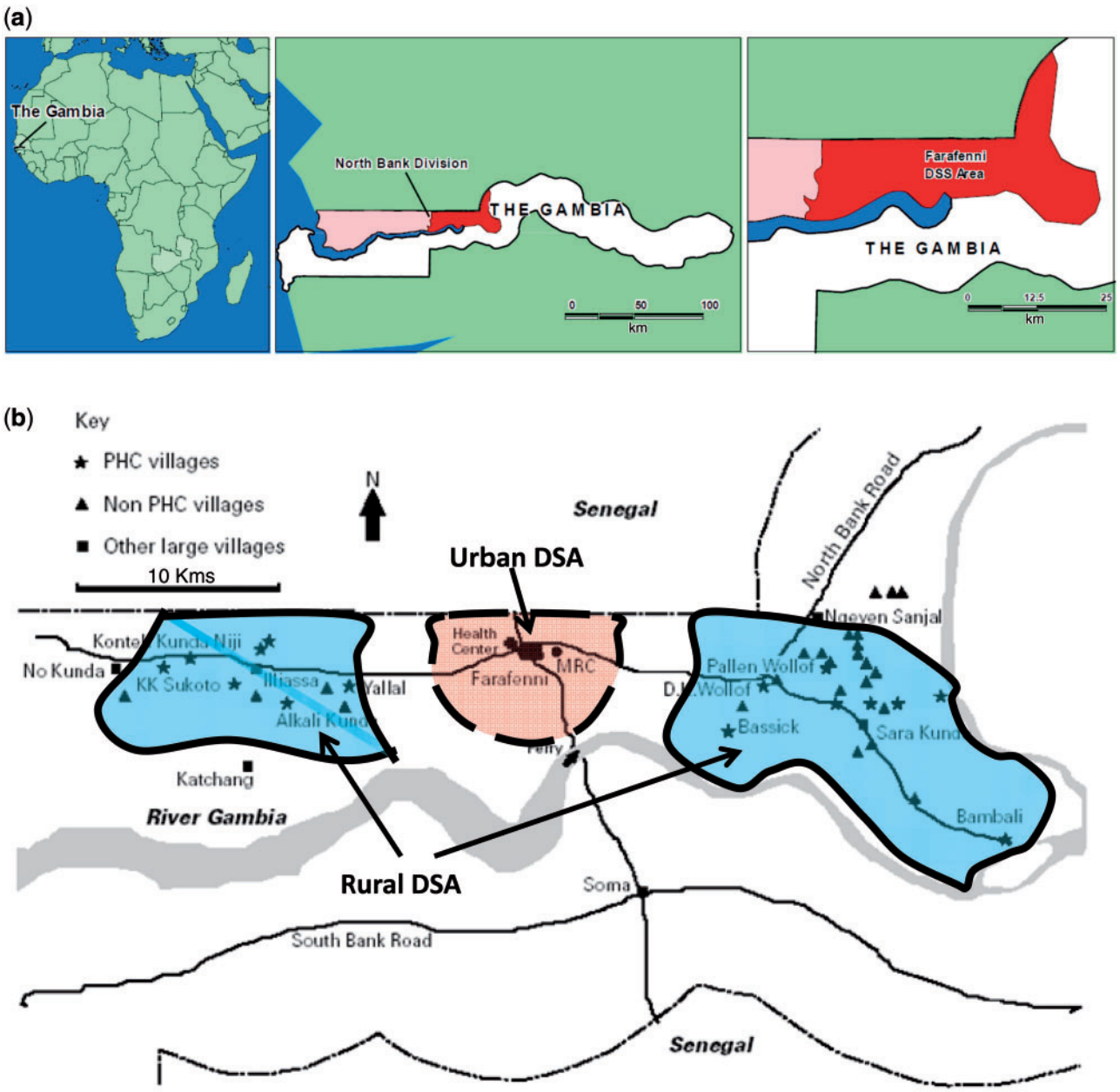

Figure 1. Location of: (a) the North Bank Region in The Gambia in West Africa; and (b) the Urban and Rural demographic surveillance areas of the Farafenni HDSS.

Who is covered by the HDSS and how often have they been followed up?

The Farafenni HDSS covers all individuals resident in the designated areas. Residents of Farafenni town and surrounding villages live in compounds (Figure 2), each of which is demarcated by a fence. Residents of each compound are organized in households. Most compounds in the rural villages have single households, whereas it is common to see several households renting apartments within a compound in Farafenni town. A household is defined as a person or group of persons living in the same house or compound, sharing the same cooking arrangements.

Until 2005, surveillance focused on two primary units, the compound and the individual. All residents were assigned a unique 9-digit identification number comprising the 3-digit village code, the 3-digit compound number and a 3-digit personal number serially assigned to residents of each compound. This grouping of individuals by compound made it impossible to conduct studies with the household as the unit of analysis. Therefore, from January 2005, residents of each compound were grouped into households with a head identified for each household, and numbered serially within the compound with two digits appended to the existing compound address to create

Figure 2. Typical compound setting in a village in the Farafenni HDSS area.

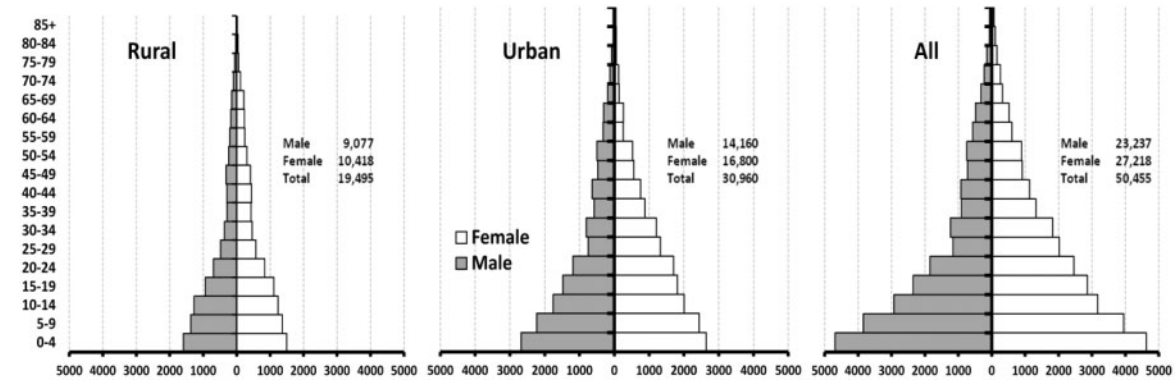

Figure 3. Age structure of the Farafenni surveillance population by area as at 31 December 2012.

unique household IDs. The household then became the third primary unit of surveillance.

Individuals enter the surveillance population through initial enumeration, birth in the area or in-migration. The total population under surveillance on 31 December 2012 was 50 455 living in 6668 households and 3382 compounds, and characterized by youthfulness and a fairly rapid growth rate (Figure 3), indicating a relatively constant but high level of fertility. At least 17% of the residents of each part of the DSA are under 5 years of age; 49% and 44% are below the age of 15 years in the rural and urban areas, respectively. The surveillance population includes three main ethnic groups—Wollof (41%), Mandinka (31%) and Fula (22%). The majority are Muslims and farming is the primary occupation of most adults.

The initial census was conducted in 1981 and surveillance procedures adopted between 1983 and 1989 are described elsewhere.[11] A change in data collection and management procedures in 1989 required fieldworkers to visit every compound under surveillance at least once every quarter to update the survival and residency status of every resident. Resident village reporters, volunteers recruited and trained on the recording of demographic events within their villages, keep records of births, deaths and migrations in and out of their villages. This information is used by the fieldworkers to cross-check data collected during compound and household visits (Figure 4). Each household has a household registration book (HRB) containing the details of all household members and associated past events. These details are listed in Table 1. Using these registration

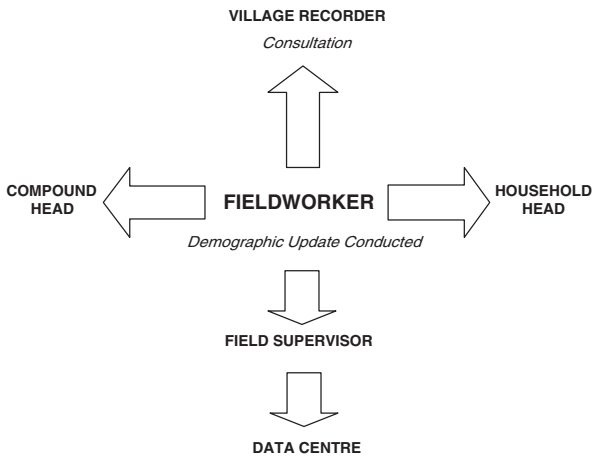

Figure 4. Data collection procedure during routine update of demographic events for a household.

books, fieldworkers interviewed the heads of households to verify and update the status of individual members every 3 months up to February 2008, and then every 4 months since April 2009 (Figure 5). Through this procedure, deaths, births, migration within or beyond the surveillance area, pregnancies and marriages are recorded. Pregnancies are followed to record their outcome (miscarriage, stillbirth or live birth), to ensure complete ascertainment of early infant deaths.

What has been measured and how have the HDSS databases been constructed?

Initially, the HDSS focused primarily on measurement of disease prevalence, especially malaria. Initial studies on malaria established the high burden of the disease and led to investigations of methods of preventing the infection such as antimalarials and/or insecticide treated bednets (ITNs).[12–17] The randomized controlled trials conducted in the area between 2000 and 2008, which drew participants from the Farafenni HDSS platform, are listed in Box 1.

Maternal mortality was measured systematically, starting with an assessment of the influence of PHC on birth outcomes and maternal health.[18] The first field trial of the 'sisterhood' method of indirectly estimating maternal mortality was conducted using the Farafenni HDSS platform.[19] Two studies conducted in 1992 and 1994, respectively, measured the level of fertility in the rural segment of the DSA, as well as its proximate and cultural determinants.[20,21] There has also been an attempt to measure male fertility and reproduction.[22] The rural villages were used to determine the impact of the PHC programme on child survival at two different time points a decade apart.[2,3,23,24] The estimates of childhood mortality generated by these enquiries were updated to track trends in under-5 mortality.[23–25]

The HDSS data were managed manually between 1981 and 1986 through registers updated through 2-yearlycensuses. Computerized management of HDSS data began in March 1986 using a dBASE II database management system to construct and manage the HDSS database, followed by dBASEs III and IV.[11] In 1998, data were migrated into a relational database system, the household registration system (HRS2),[26] a DSS-specific database management system developed for use at the Navrongo HDSS in Ghana.[27] However, loss of data on births between October 1981 and March 1989 during migration between systems rendered the data for that period unreliable for analysis.

A bespoke system was designed in 2005 using the SQLServer Express database with an MS Access 2000 front end that replicated the HRS2 interface but which allows certain types of events and episodes to be monitored better, particularly in terms of validation of data at time of entry. This provided an SQL Server equivalent database which was migrated to an SQL Server in 2006. Customized extractions from the database are currently done in SQL.

Key findings and publications

Three decades of surveillance have documented several demographic and epidemiological changes. Table 2 provides details of the population size and mortality indicators within different age brackets in four 5-year periods between 1993 and 2012. The overall population grew at a rate of 1.4% per annum between 2002 and 2012. Whereas the crude birth rate had remained virtually unchanged over the past two decades, the crude death rate dropped by 60% from 15 to 6 per 1000, leading to an appreciable rise in the rate of natural increase from 22 per 1000 in 1993–97 to 31 per 1000 in 2008–12. This demographic transition is being driven mainly by substantial improvements in child survival, which have resulted in an average gain of 13 years in life expectancy at birth in two decades.

Child survival

Prior to the introduction of the PHC programme in 1982, the infant mortality rate (IMR) was 142 per 1000 live births and the annual child (1–4 years) mortality 43 per 1000; the main causes of death in children after the first month of life as determined by VA were acute respiratory infections, malaria and chronic diarrhoea.[28] Neonatal mortality was estimated at 65 per 1000 live births and resulted mainly from prematurity and infections.[18] Considerable declines in childhood mortality indicators were observed in the years following the introduction of the village-based PHC programme, but these were similar in both PHC and non-PHC

Table 1. Information collected at each update round every 4 months

Data item	Information captured
Compound and household details	
Village code	Unique village ID number.
Compound number	Systematically recorded and sequentially updated for new compounds
Compound head name, ID	
Household number	Updated sequentially for newly created households
Household head name, ID	
Individual details	
Name, surname	Recorded for every individual under surveillance
ID number	Nine-digit unique identifier retained throughout
Date of birth	Degree of accuracy noted
Mother's ID	
Father's ID	
Sex	
Relationship to household head	Updated when household headship changes
Educational level	Highest level attained. Updated in Sept–Dec annually for school-going children
Residency status	Alive, died or migrated out of DSA
Marital status (women only)	Marriages, divorces, widowhood, husband ID
Pregnancy outcome	
Delivery	Date
Outcome	Live birth, stillbirth, miscarriage
Birth	Individual details of newborn as listed above
Death	
Date of death	
Place and cause of death	Home, hospital, health centre, etc.; and cause established through verbal autopsy and based on ICD-10.
Migration	
Migration out of DSA	Departure date, destination (if known)
Migration into DSA	Arrival date, origin, arrival location, individual details. Original details retained for returnees
Internal migration (within DSA)	Move date, departure and arrival locations, move type (i.e. change of household or compound for village level moves)
Vaccinations	
Vaccination history	Date received for all national EPI recommended vaccines
Child health information (introduced 1 January 2014)	
Birth details	Place of birth; type of delivery; assistance at delivery.
IPTp	Drug type used by mother and number of doses
Birthweight	
Breastfeeding	Time initiated and duration

ICD-10, International Classification of Diseases-10. IPTp, Malaria intermittent preventive treatment in pregnancy.

villages and the programme had no significant effect on nutritional status or vaccine coverage.[3]

By the mid-1990s, IMR had dropped by a third in PHC villages and by up to a half in non-PHC villages, and child mortality rates declined by 20% and 24%, respectively.[24] Although coverage levels remained high for many individual vaccines, only half the children in the DSA (52%) achieved full immunization status (i.e. had received Bacillus Calmette–Guérin (BCG) vaccine, three doses of oral polio vaccine (OPV), three doses of the combined diphtheria, tetanus and pertussis (DTP) vaccine and measles vaccine by 1 year of age) and the uptake of vaccines required later in the schedule has been relatively low.[29] Nevertheless, the under-5 mortality rate has continued to decline in the past decade, reaching 45 per 1000 live births in 2008 with the area achieving its MDG4 goal 7 years in advance (Figure 6,A), a

Figure 5. A fieldworker interviewing a household representative to update demographic events and residency status of household members since his previous visit.

Box 1. Randomized trials conducted on Farafenni HDSS

1. The impact of antimalarial treatment upon the development and persistence of *Plasmodium falciparum* gametocytes *in vivo* and *in vitro*: a randomized trial of chloroquine (CQ), sulfadoxine plus pyrimethamine (SP) and CQ plus SP.
2. The impact of antimalarial treatment upon the development and persistence of *Plasmodium falciparum* gametocytes *in vivo* and *in vitro*: a randomized trial of sulfadoxine/pyrimethamine (SP) and artemether plus lumifantrine (CO-artemether).
3. A randomized, controlled, double-blind efficacy trial of deoxyribonucleic acid (DNA)/modified vaccinia virus Ankara (MVA) multiple epitope (ME)-thrombospondin-related adhesion protein (TRAP) prime-boost immunization against malaria infection in Gambian adults.[39]
4. Intermittent sulfadoxine-pyrimethamine (SP) to prevent moderate/severe anaemia and low birthweight secondary to malaria in multigravidae: a randomized placebo-controlled trial in The Gambia.[33]
5. Randomized controlled trial of amodiaquine plus artesunate, amodiaquine plus sulfadoxine-pyrimethamine, and chloroquine plus sulfadoxine-pyrimethamine in Gambian children.
6. Effect of two different house screening interventions on exposure to malaria vectors and on anaemia in children in The Gambia: a randomized controlled trial.[34]

result probably due at least in part to the scale-up of effective malaria control measures such as intermittent preventive treatment and ITNs.[25]

The age pattern of childhood mortality has changed as a result of the recent decline in childhood deaths. Gains have been seen primarily in those aged 1–59 months and the proportion of neonatal deaths has consequently increased substantially and become a major public health concern (Figure 6B).

Morbidity and mortality burden of malaria

Key studies on malaria conducted in the Farafenni area included early studies on the protective role of ITNs against malaria in children,[30] a series of clinical trials that tested the efficacy of single and combinations of drugs on uncomplicated malaria in children[15,31,32] and pregnant women[8,33] and interventions aimed at preventing transmission.[34] In 1982–83, the malaria mortality rate was estimated at 6.3 per 1000 per annum in infants and 10.7 per

Table 2. Demographic characteristics of the Farafenni HDSS, 1993–2012

Characteristics	1993–97	1998–2002	2003–07	2008–12
Mid-term population	16446	17136	45217	48283
Births	3067	3518	8133	8916
Deaths	1215	1325	1908	1515
Crude birth rate (per 1000)	37	41	36	37
Crude death rate (per 1000)	15	15	8	6
Total fertility rate (no. of children per woman)	5.6	5.8	4.7	4.5
Neonatal mortality rate (per 1000 live births)				
Males	23	26	17	11
Females	15	22	13	11
Both sexes	19	24	15	11
Infant mortality rate (per 1000 live births),				
Males	80	69	40	23
Females	66	70	30	22
Both sexes	73	68	35	23
Child mortality rate (per 1000)				
Males	118	91	37	22
Females	117	83	31	21
Both sexes	117	88	34	22
Under-5 mortality rate (per 1000 live births)				
Males	189	154	75	45
Females	176	147	60	43
Both sexes	182	151	68	44
Adult mortality rate (per 1000)				
Males	343	334	335	244
Females	262	268	245	191
Both sexes	296	296	291	217
Life expectancy at birth (years):				
Males	51	53	59	65
Females	54	56	65	67
Both sexes	53	54	62	66

1000 in children aged 1–4 years.[5] Post-mortem questionnaires used at that time suggested that up to a quarter of deaths among 1–4-year-olds were caused by malaria. Between 1998–2000 and 2004–08, physician-coded VAs showed that mortality in infants caused by acute febrile illness without seizures dropped from 16.2 to 4.2 per 1000 person-years, and from 5.2 to 1.7 per 1000 person-years in children aged 1–4 years—declines of 74% and 67%, respectively. Deaths from febrile illness associated with seizures among 1–4-year-olds declined by 84%, from 4.9 to 0.8 per 1000 person-years during the same period.[25]

Maternal mortality

Estimates of maternal mortality rates have ranged widely from 1005 per 100 000 births obtained during the first field trial of the 'sisterhood method', with a reference date of around 1975,[19] to 2362 per 100 000 live births for the period 1982–83 derived from a prospective follow-up of pregnant women.[18] The most recent estimate of 424 per 100 000 live births for the period 1993–98 was derived from a reproductive age mortality survey.[35] It is apparent that there had been a drastic drop in maternal deaths, but the level remains extremely high by developed world standards.

Causes of death

Using InterVA-4,[36] analysis of 2275 VAs out of 3203 deaths that occurred between 1998 and 2007 in the Farafenni HDSS revealed that communicable diseases accounted for half (49.9%) of the deaths in all age groups, dominated by acute respiratory infections (ARI) (13.7%), malaria (12.9%) and pulmonary tuberculosis (10.2%).[37] The leading causes of death among infants were ARI (5.59 per 1000 person-years) and malaria (4.11 per 1000 person-years). Mortality rates in children aged 1–4 years were 3.06 per 1000 person-years for malaria, and 1.05 per 1000 person-years for ARI. Pulmonary tuberculosis and communicable diseases other than malaria, HIV/AIDS and ARI were the main killers of adults aged 15 years and over. Stroke-related mortality increased over the period to become the leading cause of death among the elderly aged 60 years or more in 2005–07.

All publications based on the Farafenni HDSS are listed on the MRC website: [http://www.mrc.gm/our-research/unit-publications].

Plans for future analysis

Priority for the short term will be on further analysis of causes of death. Particular attention will be focused on levels, trends and causes of adult mortality, which will form the basis for future specialized investigations on specific non-communicable diseases (NCDs). Detailed analysis of the risk factors and causes of neonatal mortality will be undertaken to characterise population-based strategies with a potential to reduce neonatal mortality.

Household-level socioeconomic surveys conducted in 1998, 2007 and 2013 will offer a unique opportunity to ascertain the extent of household-level socioeconomic

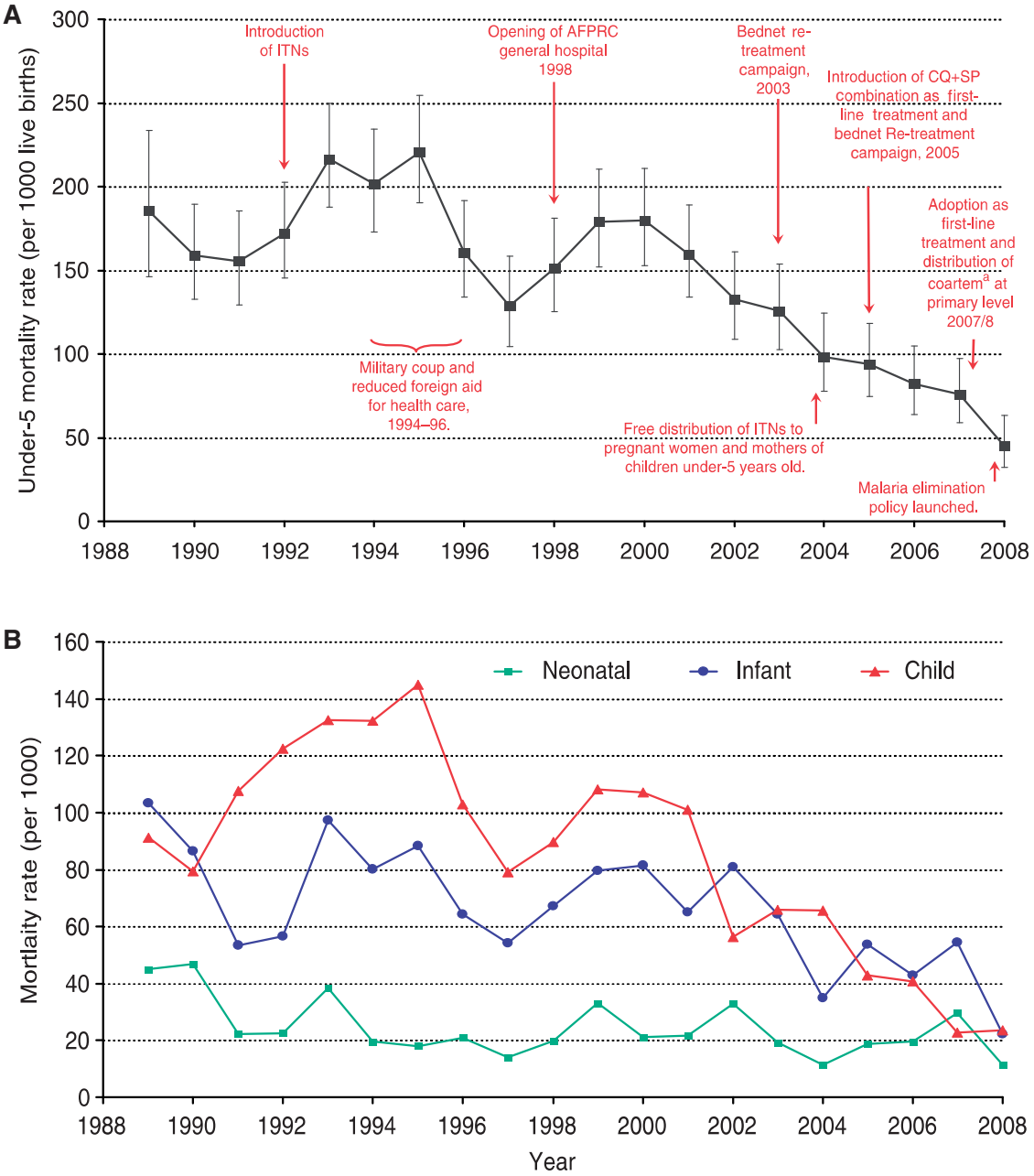

Figure 6. Childhood mortality trends in the Farafenni HDSS.[25] A Trend in under-5 mortality annotated with key health-related events. B Trends in neonatal, infant and child mortality. CQ, chloroquine; SP, sulfadoxine plus pyrimethamine.

advancement. These will be analysed alongside demographic and health data to determine the impact of changes in socioeconomic status on health and mortality. Collaborations with health economists and sociologists in the north and south will be sought to maximize the use of the socioeconomic datasets.

Appropriate instruments will be designed to collect relevant health information on infants and circumstances during the perinatal period, adolescents, adults and the elderly. This is intended to enhance our understanding of the health-related problems and challenges throughout the entire life course of residents in this part of Sahel West Africa, and is in line with the concept of universal health coverage proposed by the World Health Organization (WHO) in the post-2015 global health agenda. Specific cohorts of those with conditions of interest will be established, and necessary biological samples collected periodically for outcomes of interest. This will be particularly suited for detailed prospective community-based studies relating to NCDs such as diabetes and hypertension, as well as following the evolution of the malaria burden in The Gambia—which is declining.[38] The linkage of the HDSS database with the record-keeping system of the AFPRC General Hospital will also be explored. Detailed

mapping of the surveillance areas will be undertaken and global positioning system (GPS) coordinates of every compound recorded to facilitate spatial analysis of health and demographic indicators.

Main strengths and weaknesses

The greatest strength of the Farafenni HDSS lies in its longevity. The rural DSA has been active for over 30 years, and the urban DSA for 10 years. This period has been characterized by marked changes in general socioeconomic status of households and advancement of the local economy and facilities. It has also witnessed the introduction and implementation of major national public health interventions and programmes, ranging from PHC in the early 1980s to the national integrated management of childhood illness (IMCI) strategy, distribution of ITNs, and reproductive and child health programmes. The platform has the capacity to host a range of scientific investigations requiring prospective follow-up of participants by virtue of its system of tracking movements of individuals up to the household level. Studies of communicable disease requiring identification and recruitment of contacts for index cases can also be accommodated. The system continues to receive the commitment and support of relevant regional, district and village authorities, as well as the cooperation, confidence and trust of the residents which have developed from the health care provided previously through MRC clinics and studies.

However, loss of data on births for the period 1981–89 is a weakness of the system. Despite the fact that much of the data for this period had been published, current and future retrospective investigations will only go as far as 1989 and not to the start date of the HDSS in 1981. Also, environmental surveillance and measurement of relevant entomological indicators and population level health indicators are not undertaken routinely and linked to the HDSS database. The site is not directly affiliated to a university, but serves as a platform for training in global health at master's and doctoral levels for students affiliated to universities in the UK and New Zealand.

Data sharing and collaboration

The core demographic data for the period 1993–2010 are publicly available as part of INDEPTH Stats [http://indepth-ishare.org/indepthstats/indepthstats/StatPlanet.swf]. Further collaborations with interested individual scientists and institutions are needed to maximize use of the data, especially in cases where there is potential to influence policies relating to child survival, general well-being and socioeconomic advancement. Requests for collaborations and access to data should be directed to [mjasseh@mrc.gm].

Collaborations are welcome from established expert groups interested in jointly analysing the HDSS data to inform public health policies relevant to The Gambia and the West African sub-region. Enquiries and expressions of interest can be directed to [mjasseh@mrc.gm]. Scientific proposals, once discussed and agreed, have to be submitted using a prescribed form (available on request from [scc@mrc.gm]) and approved by the MRC Scientific Co-ordinating and Gambia Government / MRC Joint Ethics Committees before anonymized data can be made available.

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