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Cohort Profile

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Cohort Profile: The Kiang West Longitudinal Population Study (KWLPS)—a platform for integrated research and health care provision in rural Gambia

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Why was the cohort set up?

Research on malnutrition and malaria has been conducted in the Kiang West district of The Gambia (West Africa) since 1950, initially through Professor Sir Ian McGregor's annual anthropometric and health surveys of the rural subsistence farming community in this low- and middle-income country (LMIC) setting (described in more detail elsewhere[1]). With the establishment of a permanent field station by the UK Medical Research Council (MRC Keneba) in 1974, research and health provision expanded into the wider community. MRC Keneba is located in the heart of the 750-km^2 district located in the Lower River Region, which until 2014 had limited road access (Figure 1). Research facilities in KW were initially set up to support nutrition studies, in particular for longitudinal studies of growth in four 'core villages' (with ~4000 residents). Since 1989, research studies also recruited participants from the wider district. The establishment of the comprehensive demographic surveillance [Kiang West Demographic Surveillance System (KWDSS)], electronic medical record [Keneba Electronic Medical Records System (KEMReS)] and biobanking platforms (Keneba Biobank) now comprises an integrated system for research and health care provision to the whole of the Kiang West Longitudinal Population Study (KWLPS) cohort ($N \sim 14\,000$ across 36 villages).

Since 1949, this work has primarily been supported by funds from the UK Medical Research Council (MRC) and the UK Department for International Development (DFID) under the MRC/DFID Concordat agreement.

Who is in the cohort?

The population of Kiang West is predominantly of Mandinka ethnicity (Mandinka 79.9%, Fula 16.2%, Jola

Figure 1. Map of the study area. The Kiang West district is located in the lower river division in The Gambia. Initial surveys were conducted in the core villages—Keneba, Manduar, KantongKunda and Jali (dark grey circles). The MRC Keneba field station now serves all villages in the district (light grey circles) captured by the KW Demographic Surveillance System (KWDSS). There are also two small government health centres (squares labelled M). A midwife is stationed in Jiffarong and the nearest hospital is in Bwiam (square labelled H) outside the district on the main road to the coast, respectively (for more details see Supplementary materials, available as Supplementary data at *IJE* online).

2.4%, other 1.3%) living across some 36 villages. Villages are divided into compounds, where extended multi-generational families live together with an average of 16 people per compound (range 1–170). This predominantly Muslim society practises polygamy. Rural subsistence farming is the main livelihood. Income and eating patterns fluctuate strongly according to the annual farming calendar, heavily influenced by the annual rainy season (June to October). Although more than half of the Gambian adult population has not received any education, with higher proportions in rural areas, the gross enrolment ratios for lower basic (ages 7–12 years) and upper basic (ages 13–15 years) education are around 88% and 66%, respectively, with an increase in the number of girls attending school over the years; approximately half of the children not in lower basic education attend Islamic schooling.[2,3]

The 'core' villages of Keneba, Manduar, Kantong Kunda and for a limited period Jali, have been the subject of longitudinal demographic and health surveys since 1950. In 1974 and 1977 respectively, regular outpatient and antenatal clinics were established at the MRC Keneba field station to serve the medical needs of these villages. Health care provision and research studies after 1989 started to extend beyond the core villages in the wider Kiang West District (Figure 2).

Figure 2. Schematic representation of time lines of data collection in Kiang West. Studies and surveys, especially those since 2000, are contained within the Kiang West Longitudinal Population Study (KWLPS) electronic databases.

Since 2004, all Kiang West residents are captured by the KWDSS; this now forms the backbone of the data flow structure and participant recruitment for all MRC research studies in the region (Figure 3). In 2009, the KEMReS was launched to capture detailed morbidity data of Kiang West citizens for all primary health care contacts with the clinic at MRC Keneba. The Keneba Biobank was established in 2012. All recent and ongoing research projects are linked to one or more elements of the platforms triad KWDSS/KEMReS/KenebaBiobank. Data capture using electronic tablets has been introduced for our most recent studies in the region. Study-specific databases are not described here in detail, but we refer the reader to the references in the findings section below and our publication list via the MRC ING website [www.ing.mrc.ac.uk]. However, information on longitudinal databases (i.e. core village and other longitudinal data), as well as systematically collected data, is given in the following sections. Summary statistics for the KWLPS cohort are shown in Table 1 and also in Supplementary Figure 1 (available as Supplementary data at *IJE* online).

How often have they been followed up?

Core village and historical data

The conduct and content of demographic and health surveys, clinics and vaccination programmes before 2004, as well as the resulting reduction in mortality, have been described in detail by Rayco-Solon and colleagues.[1] Medical data at the MRC Keneba clinic were collected on paper before 2009. Data of structured child welfare clinics, vaccinations and antenatal clinics were entered into a database for those residing in the core villages since around 2000 (Figure 2). The remainder of medical data recordings for Kiang West residents beyond the core villages was not electronically transcribed before 2009.

KWDSS

The main purpose of the KWDSS is to provide reliable and up-to-date demographic data on the population of the Kiang West, to support the many research projects conducted by the MRC in the district. In particular it provides:

i. a common numbering system for all Kiang West residents and study subjects;
ii. accurate dates of birth and identification of parents;
iii. a sampling frame for study participant selection;
iv. population structure, used to facilitate the design/assess feasibility of new studies;
v. residence histories for survival analyses;
vi. and tracking of individuals' movements, to facilitate longitudinal and follow-up studies.

Figure 3. Database structure and data flow for the Kiang West Longitudinal Population Study (KWLPS) cohort. For further details on the KWLPS databases see Supplementary materials (available as Supplementary data at *IJE* online).

Table 1. Summary statistics of the Kiang West Longitudinal Population Study (KWLPS) cohort in 2013 and of The Gambia national data in comparison

Parameter	Kiang West	The Gambia	Unit
Total population	14 846	1 967 709[2]	Inhabitants
Crude birth rate	34.86	30.06[2]	Births per 1000 people
Total fertility rate	5.50	3.73[2]	Babies per lifetime
Crude death rate	6.40	7.17[2]	Per 1000 people
Neonatal mortality rate	23.44	22[3]	Per 1000 births
Post-neonatal mortality rate	15.63	12[3]	Per 1000 births
Infant mortality rate (aged < 1 year)	39	34[3]	Per 1000 live births
Child mortality rate (1–4 years)	6	20[3]	Per 1000 live 1-year-olds
Under-five mortality (< 5 years)	45	54[3]	Per 1000 live births
Crude rate of natural increase	28.46	24.49	Per 1000 people (birth rate minus crude death rate)
In-migration rate	89.86	N/A	Per 1000 people
Out-migration rate	88.91	N/A	Per 1000 people
Life expectancy at birth, female	73.46 (64.94, 81.98)	63 (N/S)[12]	Years (CI 95%)
Life expectancy at birth, male	65.28 (58.71, 71.84)	59 (N/S)[12]	Years (CI 95%)

N/A, not applicable; N/S, not specified.

Every individual who has been resident in Kiang West since 2004, and all who have taken part in our studies before that date, are assigned a unique identity number (ID), the West Kiang number (WKNO). Every compound in the district is visited once every 3 months according to a fixed schedule. The first 2 months of each cycle are dedicated to routine visits and the third is set aside to resolve discrepancies and double registrations and link the unique ID of the parents of newly registered individuals, linking district-internal migration movements and conduct quality assurance. At each visit a senior member of the compound is interviewed to provide the required information.

Since the KWDSS is used as a sampling frame within the KWLPS cohort, maintaining the integrity of the linkages within the KWDSS, and between it and other databases, is critical. In order to achieve this, we impose two basic constraints: (i) no individual can be recruited by a study or the clinic until they have been assigned a unique ID number; and (ii) no delivery can be recorded in the maternity database unless the mother has an 'open' pregnancy episode recorded. It is also often necessary to find the unique ID number of an individual based on limited information, but this is not always a straightforward task in a setting such as rural Gambia. For this purpose we devised a search utility, the 'Demography Search using Bayes' (DSUB) algorithm to search the KWDSS database for individual(s). The user may input whatever is known of the individual and the programme outputs the best matches. The KWDSS is a registered INDEPTH Network [http://www.indepth-network.org/] member centre. Additional information on the KWDSS, including the search algorithm, is given in the Supplementary materials (available as Supplementary data at *IJE* online).

KEMReS

The primary health care clinic at the MRC Keneba field station (Figure 1) provides general health care to all Kiang West citizens who present with acute or chronic medical conditions. Around 1500 patients, excluding visitors to Kiang West, are seen each month, with seasonal variation (Supplementary Figure 2, available as Supplementary data at *IJE* online). Children aged under 5 years attend the clinic in Keneba about four times per year, depending on the village of origin within the district and transport availability. Emergency presentations are seen 24 h per day. General, child welfare, antenatal/postnatal and non-communicable disease (NCD) clinics are run weekly. An observation room allows stabilization of patients, but full inpatient facilities are not available. Patients requiring treatment at a secondary/tertiary medical facility get transported to either the clinic at MRC Fajara or the Edward Francis Small Teaching Hospital (formerly the Royal Victoria Teaching Hospital) in Banjul, both 2–3 h by road.

KEMReS started recording patient attendances in December 2009 and was designed to capture clinical data of all presentations at the clinic at MRC Keneba across all age groups, to: understand in depth the epidemiology of communicable and non-communicable diseases; support ongoing research projects; and improve clinical care for the population. The database also incorporates data on regular child welfare clinics (for those aged < 2 years) and vaccinations. Electronic capture of antenatal/postnatal information was added to KEMReS in 2013. KEMReS as a platform in conjunction with the other databases can provide details on adverse events and/or morbidity data as outcome measures for clinical trials in the district. For more detail on the KEMReS set-up access, see Supplementary materials (available as Supplementary data at *IJE* online).

Keneba Biobank

The Keneba Biobank was initiated in May 2012, as a platform for genetic studies and the collection of biological samples and simple phenotypic measures for all consenting individuals captured by the KWDSS. A custom-designed database and sample tracking system was introduced, which is used for all Biobank-related processes. The Keneba Biobank is currently in its first round, with recruitment standing at > 9000 participants to date. To ensure an even distribution of recruitment by season, the region was block randomized into 10 sectors of roughly equal size comprising either a single village or several smaller villages. Every 2 weeks, recruitment moves to a different sector, with all sampling and most measures conducted in the field. Participants are visited in the early morning to obtain age group-specific data and (fasted) biological samples. Clinical referral criteria were defined to identify urgent referrals (malaria or severe high blood pressure) observed during the field visit. Affected participants, as well as those who report feeling sick, are brought back to the MRC Keneba clinic on the same day for evaluation by a clinician. Non-urgent referrals (high glucose level, high blood pressure, anaemia) are identified via a search function within the Keneba Biobank database, and cases are called within a few days for re-testing and clinical evaluation during regular clinics (e.g. the weekly NCD clinic).

The Keneba Biobank is part of the LMIC Biobank and Cohort Network (BCNet), [http://bcnet.iarc.fr/].[4] Additional information on the Keneba Biobank is given in the Supplementary materials (available as Supplementary data at *IJE* online).

What has been measured?

Core village and historical data

The KWLPS database comprises computerized records of all Kiang West residents ($N \sim 14\,000$). For core village residents ($N \sim 4000$) these date back to 1950,[1] representing life-course longitudinal nutritional and health phenotypes, particularly relating to anthropometry/growth and maternal health. The consistent and longitudinal recording of the following measures were introduced over time.

- Since 1949: exact date of birth and parents' IDs.
- Since 1980: birth (weight, length, gestational age, delivery date); growth (weight, height, mid upper-arm circumference, head circumference) for children on up to 12 occasions before 2 years of age and less frequently thereafter); demographics (parents' IDs), pregnancy outcomes and reproductive histories; records of self-referrals to clinic; and outcome measures from numerous specific studies.
- Since 1990: most studies include anthropometric measurements, blood pressure, dietary and lifestyle information and blood and urine samples. In selected study groups, detailed data on bone mineral content and density, bone dimensions and more recently bone age, and muscle force and power have been measured.
- Since 1996: vaccinations.

Please note that details of study databases are not described here; further information can be found in the findings section below and via the MRC ING publication list [www.ing.mrc.ac.uk].

KWDSS

During each KWDSS round, the following information is captured: migration movements, into and out of the compound (both internal and external, including contact details for those leaving the district), births and deaths, pregnancies (to avoid missing infants who die during the neonatal period), marriages and the names or unique IDs of the parents of all newborns or new arrivals. Details of husbands of married women are mostly recorded to identify the children's fathers. All changes in status for each Kiang West citizen are captured.

An important feature of the KWDSS is that we allow data to be recorded from other sources. For instance, births and pregnancies may be derived from the maternity arm of KEMReS. Similarly, information is rectified when patients present to the general MRC Keneba clinic. This ensures that dates of birth are recorded accurately and up-to-date data on individuals are available from a single database table without needing to wait for the next KWDSS round.

The two main types of data tables used by KWDSS are 'constant' and 'episode' (for details see Supplementary materials, available as Supplementary data at *IJE* online). Briefly, constant tables are mostly used to record unchanging data such as name or date of birth. Episode tables record details of time intervals, e.g. the residency of an individual living in a particular compound.

KEMReS

KEMReS records a set of data entry fields for each stage during a patient encounter based on well-known clinical examination routines [Supplementary Figure 3 (available as Supplementary data at *IJE* online) and Table 2[5]]. Recorded information includes data on anthropometry, vital signs, symptom history and examination findings, laboratory investigations, diagnoses and prescriptions provided. Data are stored with two specified ranges according to age: (i) normal range; and (ii) possible range. An alert for the clinician/nurse appears for values out of the normal range, to address the finding clinically. A full data set at each stage needs to be entered before the patient can proceed. This ensures the accuracy and completeness of data collected at each clinic visit.

Past encounters and medical history are stored and updated with each patient encounter to aid clinical assessments and medical decisions. Diagnoses are recorded using the WHO ICD-10 coding system.[6] Diagnoses also include: 'Well with a complaint'; 'Well without a complaint'; and 'Unknown diagnosis'. A free text entry can be used to describe possible diagnoses further. KEMReS is not a clinical decision support system, although this can relatively easily be added. However, KEMReS consists of a number of user interfaces with several functionalities including clinical care reports, referral letters, management reports and medication dispensary reports. Furthermore, alerts are set for due vaccinations and drug prescriptions, to be in line with international guidelines on patient management[7].

Keneba Biobank

Table 3 shows a summary of data and samples collected as part of the Keneba Biobank by trained staff using standardized operating procedures. Briefly, agegroup-specific data and samples collected comprise: biological samples (venous blood, urine); questionnaire; anthropometry, body composition based on bioelectrical impedance (using population-specific equations[8]); and blood pressure. Biological sample processing and a limited number of analytical tests are conducted on fresh specimens at the MRC Keneba field station. Analytical tests conducted comprise fasting glucose, malaria, zinc protoporphyrin (discontinued in 2014)

Table 2. Data collected in the Keneba Electronic Medical Records System (KEMReS) during each patient encounter

Data collection stage	General description of data stored
Reception	• Demographic data retrieved from KWDSS on arrival and updated if required • Type of clinic visit (emergency, self-referred, follow-up, child welfare clinic, antenatal, research)
Triage	• Anthropometry data after double entry by trained staff: ◦ Weight (all ages) ◦ Height/length (once above 25 years) ◦ Head circumference (HC) (< 3 years) ◦ Skinfold thickness (SFT) (all ages) ◦ MUAC (< 5 years) • Vital signs and triage assessment data: ◦ Blood pressure, heart rate, respiratory rate, temperature, oxygen saturation ◦ Glasgow coma score ◦ WHO emergency signs (tick-boxes)[5] ◦ WHO priority signs (tick-boxes)[5] Clinical triage (emergency/priority/routine)
Doctor/nurse	• Vaccination record data (either given in the clinic or from infant welfare care) • Details of past medical history: ◦ All previous clinic visits since start of KEMRES ◦ All known medical conditions of importance ◦ Birth history, drug history, drug allergy history, family history ◦ Status of breastfeeding (for all women aged 14-50 years) • Present complaints (tick boxes for all systems) plus free text for additional information • Physical examination details (combination of drop-down lists and tick-boxes for each body system); free text available for any further comments • Requested investigations—linked to laboratory • Diagnosis with associated ICD-10 code;[9] free text for specification or if diagnosis not available; tick-boxes for 'Well with complaint', 'Well without complaint' or 'Routine child health examination' • Drug prescriptions: alerts for drugs presented; drug doses, frequencies and durations recorded and set according to British National Formulary (BNF) guidelines.[10] Restrictions for particular drugs for certain patient groups, e.g. aspirin not available for children under 12 years • Information on suggested discharge from clinic and follow-up: ◦ None ◦ Admission to observation room ◦ Admission to nutritional rehabilitation centre ◦ Referral for secondary/tertiary care • Information on planned review • Option for referral letter print-out
Midwives	• Obstetric history (including date of last menstrual period, previous pregnancies and modes of delivery) • Antenatal clinic visit (including fundal height measurements) • Delivery (including place, mode and time between rupture of membranes and start of labour) • Baby check (including congenital abnormalities, gestational age based on Dubowizc) • Postnatal (including any post-partum bleeding)
Laboratory	• Details of all investigations available at MRC Keneba: blood film (thick/thin), blood glucose, sickle test, HIV test, HcG, VDRL, blood group, sputum acid-fast bacilli (AFB), full blood count (FBC), blood culture (children only), urine analysis, stool examination; free text for additional information
Dispensary	• Check doctor's prescription • No data entry apart from a record of drugs actually issued
Check-out	• No data entry • Check whether all stages have been completed and investigations done and reviewed • No check-out possible if clinic visit incomplete • Paper check-out printed for filing

Table 3. Data and samples collected as part of the Keneba Biobank

	< 5-year-olds	5–18 year olds	18-year-olds
Questionnaire	N/A	N/A	Education, assets, medication for diabetes and hypertension received outside the district
Phenotypes	Weight, height, skinfold thickness, head circumference, mid upper-arm circumference	Weight, height, body composition, blood pressure	Weight, height, body composition, blood pressure
Field and laboratory analyses	Malaria test, ZNPP, full blood count	ZNPP, glucose, blood pressure, full blood count	ZNPP, glucose, blood pressure, full blood count
Biological samples collected	Unfasted blood (4.0 ml EDTA, 1.2 ml serum)	Fasted blood (4.9 ml EDTA, 1.2 ml LH, 4.5 ml serum) and ~3 ml urine	Fasted blood (4.9 ml EDTA, 1.2 ml LH, 4.5 ml serum) and ~3 ml urine
Biological sample aliquots banked	Whole blood, red blood cells, plasma, serum, DNA	Whole blood, red blood cells, plasma, serum, DNA; urine (spun, unspun, acidified)	Whole blood, red blood cells, plasma, serum, DNA, urine (spun, unspun, acidified)

Weight in kg to the nearest 10 g; height, head circumference and mid upper-arm circumference (MUAC) to the nearest 0.1 cm; body composition by Tanita BC-418 MA analyser; blood pressure Omron 705-CPII; fasting glucose Accu Check (Roche Diagnostics); malaria rapid test (Standard Diagnostics); zinc protoporphyrin (ZnPP) by haematoflurometer (Aviv Biomedical); full blood count by Medonic M-series 3-part haematology analyser (Boule Medical); acidified urine samples treated with concentrated hydrogen chloride; EDTA, ethylenediaminetetraacetic acid; LH, lithium-heparin.

and full blood count. Samples processing involves the separation of blood fractions (serum, plasma, washed red blood cells), treatment of urine and DNA extraction; all samples are split into several aliquots and stored in 2D-barcoded microtubes at −70°C within 2–4 h of collection.

Ethical considerations

All studies and data collections in Kiang West are presented to and approved by the MRC Unit The Gambia Scientific Committee (SCC) and joint Gambian Government/MRC Unit The Gambia Ethics committee, which is overseen by the ethics board of the London School of Hygiene and Tropical Medicine (LSHTM). For research studies, all participants and/or legal guardians provide written, informed consent.

What has it found? Key findings and publications

Summary statistics of the KWLPS cohort compared with national data from The Gambia are shown in Table 1. It is noteworthy that mortality rates have improved dramatically over the past decades,[1] with higher life expectancy in women and greater reductions in crude and child mortality rates seen in Kiang West than elsewhere in The Gambia.[2,9] Differences are likely due to higher standards of clinical services children and women receive, including regular child welfare clinics and ante- and postnatal follow-up in Kiang West, compared with other regions. Slightly higher neonatal, post-neonatal and infant mortality rates in Kiang West compared with national data probably relate to the better capture of data on deaths, since almost all pregnancies are monitored and their outcomes recorded. Table 4 shows the 10 most common medical diagnoses by age group based on ICD-10 coding.[6] Morbidity patterns are similar to previous studies in the sub-region, with around 30% related to respiratory illness.[10] In those over 50 years old, NCDs form a large part of clinic presentations. Prevalence of malaria across the whole of the Gambian population has decreased recently[11] and, particularly in those under 10 years of age, malaria represents now fewer than 2% of all clinic presentations.

There are numerous publications describing the vast body of research conducted in the KWLPS cohort since the early 1950s, too many to list and describe. However, the key findings and publications can be broadly described under the categories of: (i) secular trends; (ii) major research findings; and (iii) recent developments. A short summary of these is given below; for a comprehensive list of references over recent years, see our publication list via the MRC ING website [www.ing.mrc.ac.uk].

i. Reports on secular trends describe declining mortality trends;[1,12,13] intergenerational and demographic transition effects on growth[14,15] and survival;[16] reductions in diarrhoea rates;[17] declining malaria rates.[11]
ii. Major research findings include: insights into season of birth or conception effects on mortality;[18] immune outcomes[19] and DNA methylation;[20] effects of pregnancy supplementation on low birthweight;[21]

Table 4. Ten most common clinical diagnoses made per age group between January 2010 and July 2014 at the MRC Keneba clinic

Age group	< 1 years			1–4 years			5-9 years			10–14 years			15–19 years			20–49 years			>50 years		
Number of clinic visits per age group (% of total overall)[a]	9712 (10)			16360 (17)			8544 (9)			9206 (10)			7730 (8)			24951 (27)			17344 (18)		
Total number of diagnoses / reasons for visit per age group[b]	13058			21254			9828			10489			8913			30464			23890		
		n	%		*n*	%		*n*	%		*n*	%		*n*	%		*n*	%		*n*	%
10 most common diagnoses / reasons for visit per age group	Common cold	3031	23	Common cold	5379	25	Common cold	1973	20	Common cold	2005	19	Common cold	1443	16	Common cold	2733	9	Hypertension	6430	27
	Routine child examination	1547	12	Viral gastroenteritis	1612	8	Skin infection	659	7	Abdominal pain	886	8	Abdominal pain	761	9	Unknown diagnosis	1906	6	Follow up examination	1871	8			
	Viral gastroenteritis	1537	12	Pneumonia	1299	6	Abdominal pain	624	6	Headache	679	6	Unknown diagnosis	430	5	Headache	1809	6	Common cold	1465	6
	Pneumonia	908	7	Follow up examination	1215	6	Pneumonia	417	4	Unknown diagnosis	498	5	Headache	326	4	Hypertension	1647	5	Backache	1248	5
	Follow up examination	901	7	Intestinal helminthiasis	1093	5	Unknown diagnosis	388	4	Skin infection	471	4	Local skin infection	297	3	Backache	1630	5	Unknown diagnosis	983	4
	Well without complaint	492	4	Local skin infection	1061	5	Headache	366	4	Conjunctivitis	316	3	Toothache	240	3	Abdominal pain	1405	5	Headache	893	4
	Conjunctivitis	447	3	Cutaneous abscess	926	4	Conjunctivitis	338	3	Injury	300	3	Tonsillitis	218	2	Urinary tract infection	1137	4	Unspecified pain	768	3
	Cutaneous abscess	376	3	Conjunctivitis	703	3	Follow up examination	316	3	Tonsillitis	281	3	Unspecified pain	206	2	Follow up examination	1077	4	Old age	693	3
	Local skin infection	364	3	Routine child examination	605	3	Injury	275	3	Sickle-cell disorders	275	3									
Dysmenorrhoea	198	2	U-	nspecified pain	1064	3	Pneumonia	692	3												
Marasmus	330	3		Impetigo	605	3	Intestinal helminthiasis	242	2	*Plasmodium falciparum* malaria	265	3	*Plasmodium falciparum* malaria	195	2	Epigastric pain	945	3	Arthritis	583	2

Diagnoses are classified according to the WHO International Classification of Diseases (ICD) and stored in KEMReS using the ICD-10 coding system.[9] The diagnoses include follow-up examinations (ICD-10 code Z09) and routine child welfare clinic examinations (ICD-10 code 700.1).

[a]Overall there were 93 847 clinic visits.

[b]A total overall of 104 839 diagnoses were made.

increased understanding of growth faltering; identification of critical windows beyond the 'first 1000 days' for possible nutritional interventions to address stunting;[22] lack of anticipated benefits of calcium supplementation in children and pregnant mothers with a very low calcium intake, with identification of unexpected, possibly adverse, long-term skeletal effects;[23–25] the use of MUAC to identify infants at increased risk of death in LMIC;[26] and the efficacy of hepatitis B vaccination after 24 years of follow-up.[27]

iii. More recent developments with respect to the KWLPS cohort are covered by the following publications on: early nutrition and immune development via a birth cohort followed up since 2010 (the ENID trial);[28] life course nutrition and health, including immune/inflammatory outcomes[29] and cognitive development;[30] the role of the iron-hepcidin axis in infection;[31,32] and seasonal effects on blood cell composition.[33]

What are the main strengths and weaknesses?

Strengths

- Stable, well-characterized and 'research-friendly' population in rural sub-Saharan Africa of highly homogeneous ethnicity. Exceptional long-term relationship between population and MRC maintained through high levels of communication between MRC staff and villages and with great care taken to ensure research ethics.
- Computerized records of all Kiang West residents, some of which date back to 1950, representing a unique level of life-course nutritional and health phenotypes including: birth anthropometry and details of mother's health and nutritional status in pregnancy; detailed serial postnatal anthropometry; active health surveillance at child welfare clinics from from birth to 24 months; records of self-referrals to clinic thereafter; reproductive histories; and outcome measures from numerous specific studies.
- A setting that facilitates research on the complex relationships between diet, health and survival in an environment where infectious diseases still play a major role in mediating population health, e.g. seasonal influences.
- Integrated demographic surveillance and clinical and biobank research platforms with standardized variable measurements using a unique identification number per person.
- Detailed pedigree records facilitating research across multiple generations.
- Custom-designed framework for KWDSS, KEMReS and Keneba Biobank databases with: user-friendly interface for use by low-information technology (IT)-skilled health professionals, laboratory and field staff; coded data rather than free text; and lists facilitating ease of data management, with clear patient/participant flow limiting missing data.
- Automated processes including the generation of consent and call lists; collection and logging of participant information on basic demographics, phenotypes and laboratory tests; collection, logging and tracking logging of biological samples.
- The majority of research platforms and ongoing studies now work on the basis of live/current direct data entry, thereby reducing the possibility of data errors.
- Large repository of banked biological samples.
- Established procedure for access to samples and data via KDSG and SCC/EC application (see below).
- Good database and IT support.

Weaknesses

- The size of the total population of Kiang West ($N \sim 14000$) is limiting for the study of, for example, rare diseases, diseases occurring infrequently in this population or in sub-groups such as women who have never been pregnant, and there is a risk of 'over studying'.
- The KWDSS system yields useful background data on the demographic status and changes in the area, although the population size is insufficient for some aspects of demographic research.
- The majority of longitudinal data are restricted to residents of the core villages ($N \sim 4000$), with Kiang West-wide ($N \sim 14000$) data collections being more recent.
- There is some bias regarding the age-sex distribution between the ages of 20 and 50, due to (temporary) out-migration to urban areas for work (see Supplementary Figure 1, available as Supplementary data at *IJE* online). However, we increasingly conduct studies and follow-ups outside the district.
- Although the mortality overall in the Kiang West district is lower than the country average, the morbidity profile is comparable across The Gambia (see Tables 1 and 3).[9]

Can I get hold of the data? Where can I find out more?

Access permission for collaborators is regulated via one or more of the following: the principal investigator of platforms/research studies; the head of MRC KenebaField Station; or head of MRC ING. Further details can be found via the MRC International Nutrition Group website [www.ing.mrc.ac.uk]. Access is controlled via the Keneba

Database Steering Group (KDSG) and/or applications to joint the Gambia Government/MRC Ethics Committee (SCC/EC).

Supplementary Data

Supplementary data are available at *IJE* online.

Profile in a nutshell

- The Kiang West Longitudinal Population Study (KWLPS) is a prospective cohort, served by the MRC Keneba field station (MRC Unit, The Gambia); it supports research particularly in nutrition, infection and growth.
- KWLPS is located in rural Gambia and started with the collection of longitudinal multi-generational data for four 'core' villages, going back to 1950. It was more recently expanded to include all residents in the Kiang West District (all ages, $N > 14\,000$ across 36 villages), enabled by the introduction of linked database systems and platforms: the Kiang West Demographic Surveillance System (KWDSS since 2004), the Keneba Electronic Medical Records System (KEMReS since 2009) and the Keneba Biobank (since 2012).
- Follow-up for KWDSS is 3-monthly and forms the sampling frame for all ongoing and future data collections within the KWLPS.
- KWLPS comprises a wealth of demographic and phenotypic measures, genetic and epigenetic data and biological samples, facilitating the integration of research and health care provision to the whole of the population.
- Data access is managed via the MRC International Nutrition Group (www.ing.mrc.ac.uk).

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