Preventive child health services in Mangochi District Hospital, Malawi

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Introduction: Malawi was one of few sub-Saharan countries to reach the Millennium Developmental Goal 4 to reduce child mortality by two thirds. However, children in sub-Saharan Africa are 15 times more likely to die before turning five years of age compared to those in high-income countries. Preventive services such as growth monitoring, immunisation and vitamin A supplementation play an important role in reducing child mortality. The aim of the study was to identify and describe potential problems in preventive child health services in a low-income sub-Saharan setting, in Mangochi District Malawi, assess the trends in vaccination coverage and explore how the services could be improved.

Methods: Both qualitative and quantitative data was collected over the period 26 February to 17 March 2020. Qualitative data was collected with participatory observation and by conducting interviews with Health Surveillance Assistants. Quantitative data was collected for all vaccinations from 2015-2019 both in Mangochi District and Mangochi District Hospital (MDH) from the District Vaccine Data Management Tool. Data on the flow of children through the static under 5 (U5) clinic at MDH, was collected from a registration book for seven days during the period; 97 children came for vaccination services.

Results: In the period 2015-2019, more than 3 million immunisation injections were provided in Mangochi District for children. Fewest were given in 2016 and most in 2019, a difference of 33%. Through the whole period, more static sessions at the health facilities were conducted than outreach in the rural villages. The proportion of cancelled sessions, both static and outreach, rose from 2015-2017; the average proportion of cancelled outreach sessions was 72% higher compared to static sessions over the period. The coverage rate for oral polio vaccine given at birth (OPV0) was significantly lower than the coverage rate for Bacillus Calmette-Guérin vaccine (BCG) ($p=3.5*10-5$). On average, the coverage for the third dose of pentavalent vaccine (penta3) was nine percentage points lower than for penta1, with the largest difference seen in 2017 and smallest in 2019. The coverage rate was significantly lower for measles-rubella 2 (MR2) than MR1 ($p=0.01$). At MDH, on average, 589 vaccinations were given at the static clinic weekly, 14% higher compared to vaccinations provided at the outreach clinics. BCG was administered 5.9 times more often at the static than the outreach clinics, with an average coverage of 155%. On average, there were 14 visits and 40 vaccines administered daily. Most of the children (70%) were given four vaccines, and 24% of them were not vaccinated at the visit. Half of the children who had their birth registered in the registration book, were immunised timely.

Conclusion: Utilisation of health services is good both in Mangochi District and at MDH. The vaccination coverage was higher for immunisations provided earlier after birth compared to those provided later; still, not all children are reached. The facility at the static clinic has improved since the inauguration of a new maternal wing while the working conditions could still be improved with more space and staff. Further, data registration needs to be improved for all preventive child health services offered in the district.

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BCG	Bacillus Calmette-Guérin vaccine
CCE	Cold chain equipment
DHMT	District Health Management Team
DTP	Diphtheria, tetanus, pertussis vaccine
DVDMT	District Vaccine Data Management Tool
FVC	Fully vaccinated children
HBV	Hepatitis B virus
hepB	Hepatitis B vaccine
Hib	*Haemophilus influenzae* type B
HSA	Health Surveillance Assistant
IPV	Inactivated poliovirus vaccine
MDGs	Millennium Developmental Goals
MR	Measles-Rubella vaccination
OPV	Oral poliovirus vaccine
PCV	Pneumococcal vaccine
PFP	Private for profit
PFNP	Private not for profit
PHC	Primary health care
RV1	Rotarix
RV5	Rotateq
SARS-Cov-2	Severe acute respiratory syndrome coronavirus 2
SDGs	Sustainable Developmental Goals
SSA	sub-Saharan Africa
TB	Tuberculosis
U5	Under 5 years of age
U5M	Under 5 mortality
U5MR	Under 5 mortality rate
VAPP	Vaccine associated paralytic poliomyelitis
WHO	World Health Organization

1 Introduction

In 2018, it was estimated that 5.3 million children died before the age of five (1). More than half of those deaths were preventable or treatable with simple interventions such as immunisation, nutrition and clean water (1). Although the under 5 mortality rate (U5MR) has been decreasing, disparities still exist. For example, children in sub-Saharan Africa (SSA) are more than 15 times more likely to die before turning five years old than those in high-income countries (1). Leading causes of under 5 mortality (U5M) in SSA are maternal and neonatal disorders, respiratory and enteric infections, malaria and neglected tropical diseases (2). Many of these risk factors for mortality can also affect child development, in particular early childhood. Preventive services such as growth monitoring, immunisation, vitamin A supplementation, malaria prevention and health education play thus a vital role in reducing U5MR (3).

Causes for U5M of children are similar in Malawi as found in SSA countries in general (2). Malawi was one of few SSA countries to reach the Millennium Developmental Goal 4 (MDG4) to reduce U5MR by two thirds. They succeeded to lower the U5M from 247 per 1,000 live births in 1990 to 71 per 1,000 live births in 2013 (4). Malawi did that by increasing emphasis on treating childhood malaria, pneumonia and diarrhoea as well as preventing those diseases with vaccines, insecticide-treated bed nets and by reducing undernutrition (4). In 2018, the U5MR was 55 per 1,000 live births, a continued decline albeit slower than during the MDG era (5). Despite reaching MDG4, Malawi will need to keep improving preventive services to achieve the Sustainable Developmental Goals (SDGs).

The study describes preventive services and analyses immunisations coverage both in Mangochi district and at Mangochi District Hospital (MDH), Malawi.

1.1 Millennium Developmental Goals

The MDGs were agreed on by the UN General Assembly for the period 2000-2015 with the aim to tackle indignity and poverty by 2015 (6). The goals were eight and featured poverty, education, health, environmental sustainability and gender equality. There were three health goals: Reduce U5MR (MDG4), "*improve maternal health*" (MDG5) and "*combat HIV/ AIDS, malaria, and other diseases*" (MDG6) (6). Progress towards the MDGs was remarkable, and they contributed to change our world view. During the period child mortality declined by 53% between 1990 and 2015, missing the target to reduce it by two thirds and maternal mortality fell by 43%, well short of the 75% targeted (6). The improvements were however uneven between regions. The African Region and the South-East Asia Region accounted for an unequal proportion of the U5MR and maternal deaths, globally. (6).

1.2 Sustainable Developmental Goals

The SDGs are a universal agenda produced to address the challenges the world is confronting such as poverty, climate change, peace, justice and environmental deterioration. (7). It was set by the United Nations General Assembly in 2015 and is aimed to be accomplished by 2030 (6). The goals are applicable to all countries. The SDGs replaced the MDGs and include 17 goals and 169 targets (6).

Their priorities are health as a fundamental human right, poverty eradication, education, and nutrition. The SDGs are broader than the MDGs and contain a wide range of social, environmental, and economic factors. SDG3 addresses health. Its goal is to *"Ensure healthy lives and promote well-being for all at all ages"* (6). It emphasises on finishing the agenda of the MDGs, to prevent maternal, child and newborn mortality. Health is associated with many of the other 16 goals, indicating that health affects and is affected by a wide range of social, environmental, and economic objectives. SDG3 is associated with 13 targets. SDG Target 3.2 is to "*end preventable deaths of newborns and children under five years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births, by 2030*" (6). The target compares with MDG4 (6). Globally U5MR is still far from the aim. In 2017, it was 39 deaths per 1,000 live births (8). SDG Target 3.3 is to "*end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases by 2030*" (6).

1.3 Primary Health Care

Primary health care (PHC) is an approach to health and well-being focusing on the needs of individuals, families, and communities. It focuses on factors that are related to health both directly, such as the health system and access to services, and indirectly, such as economic, social and political aspects (9). PHC aims on providing extensive services, such as disease prevention and treatment, palliative care and rehabilitation. It is based on article number 25 of the Universal Declaration on Human Rights*: "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services"* (9, 10). In 1978 the Alma-Ata Declaration was introduced at the International Conference on Primary Health Care in Alma-Ata, former Soviet Union, now Kazakhstan, which is a landmark in the history of primary health. It stated that: *"Health is a state of complete mental, physical and social well-being, and not merely the absence of disease or infirmity and is a fundamental human right"* (11). PHC was defined and proposed as the plan to reach the goal Health for All by the year 2000. The definition indicated mainly health improvements in the community but underlined the importance of economic, socio-cultural and political factors (12). Since then, PHC has been redefined often and, there is no one final definition (10). It has been referred to as first contact for personal health care services and as priority health interventions for low-income countries. Others have defined it as an approach that focuses on economic, political and social aspects instead of only health services (10).

The Alma-Ata declaration was criticised for having too broad and impracticable aim: "*Health for all by 2000*". Subsequently, a new perspective was introduced, called selective primary health care, represented by the acronym GOBI which stands for: Growth monitoring, oral rehydration therapy, breastfeeding and immunisation (11). These four interventions were easy to monitor and measure. They were introduced to reduce child mortality. Later the acronyms FFF (food supplementation, female literacy and family planning) were added to GOBI, creating GOBI-FFF, an effort to improve maternal health (11).

In 2018, 40 years after the Alma Ata conference, the commitment to a comprehensive primary health care for all was renewed at the Global Conference on Primary Health Care in Astana, Kazakhstan. Once again, the importance of primary health care was emphasised in achieving universal health coverage and the health-related SDGs (13).

1.3.1 Primary health care and the SDGs

PHC related efforts can both contribute to SDG3 and several other goals. PHC and the SDGs address the determinants of health and not only those inside the health sector (14). Primary care services promote achievements of the SDGs by targeting preventive interventions, treatment, delivering health promotion and educational interventions. Countries with strong primary care have shown better health outcomes and health system efficiencies. Poor health can contribute to impoverishment (SDG1), malnutrition (SDG2) and limit education (SDG4) which shows that PHC is critical to attain the SDGs (13, 14)

1.3.2 Primary care

Primary care services are a vital component of primary health care. While PHC refers to a broad approach which aims at improving health both at individual and community level, primary care refers to clinical services for individuals and families such as promotive, preventive, curative and rehabilitative services (3). It does not focus specifically on diagnosis or treatment. Instead, it targets the provision of health services founded in the PHC approach. Primary care may be delivered by primary care professionals such as doctors or nurses or by health workers that often are community members. It has been shown that countries which have better primary care do also have better health indicators than those with less established primary care services (3). Primary care emphasises on prevention, being patient-centred and accessible along with continuity of care (3).

1.4 Immunisation

Vaccination has made a significant contribution to global health (15). It is one of the most influential public health interventions and is considered an essential health service (3). In 1974, World Health Organisation (WHO) established the Expanded Programme on Immunisation to improve the uptake of routine childhood vaccines. The programme increased the coverage (calculated by dividing administered doses of the vaccine with number of infants) for tuberculosis, diphtheria, tetanus, pertussis and poliomyelitis from <5% to 86% in 2018 (16). More than 20 life-threatening diseases can now be prevented with immunisation and during the last 15 years there has been a substantial advancement in vaccine innervation, countries are introducing several new vaccines and increased coverage with others (17). It is estimated that immunisation prevents 2–3 million deaths each year. In 2018, the global vaccination coverage for the third dose of diphtheria, tetanus, pertussis vaccine (DTP3) was 86%,

comparable to recent years. Still, an estimation of 19.4 million infants globally were not reached with routine immunisation services (18).

Although coverage of routine infant vaccinations is now high in many low- and middle-income countries children over the world have unequal access to immunisation, affected by socio-economic, demographic, and geographic factors. Those who live in poor households have lower coverage than those in rich households. Besides children whose mothers have a higher level of education are more likely to be vaccinated. Mother's age at the time of birth can also impact the probability. Generally, children fare worse if their mother is under 20 years old when she gives birth and, in some countries first-born children are more likely to be fully immunised (19).

1.4.1 Bacille Calmette-Guérin vaccine

Bacillus Calmette-Guérin (BCG) is a live attenuated vaccine to prevent tuberculosis (TB) (20). TB is a disease caused by the airborne bacteria *Mycobacterium tuberculosis.* Lungs are the most common place where infection occurs, but many organ systems can be involved. First exposure causes primary TB, which most often is subclinical lung infection but can also cause symptomatic infection. If an individual gets a subclinical infection, it can reactivate if the person gets immunocompromised, for example, because of AIDS (21). It has been shown that people with HIV are 15-22 times more likely to develop TB (20). Symptoms of activated pulmonary TB are coughing, sweating, chest pain, weight loss and night sweat. In 2018, it was estimated that globally 10 million people were sick from TB, and 1.5 million died from the disease even though it is both curable and preventable (20).

According to WHO, the BCG vaccine should be administered at birth in areas where children are in high risk of exposure of active pulmonary TB, then it is 70-80% effective (22, 23). It has been shown that it is least effective if given later, because the person, especially in areas where TB is endemic, could have developed an immune response (22). The vaccine should not be given to children with HIV, and if it was not given at birth, it should be given at the earliest opportunity (23). It causes a scar, which shows that the vaccination was applied right, and if children do not develop it, they should be vaccinated again (24). A new vaccine is considered necessary to eliminate TB. Candidate vaccines in clinical trials are both live inactivated whole-cell and live attenuated vaccines, boosters for BCG and priming vaccines (25).

It has been shown that the BCG vaccine has non-specific effects on the immune system; for example, it has been used as a treatment for bladder cancer (26). There is evidence that the vaccine can be used as a protection against other respiratory infections. Therefore, it might reduce viremia after exposure of Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and thus cause less severe disease (27). Randomised controlled trials are now running to find if the BCG vaccine is useable to reduce the severity and incidence of COVID-19 in health care workers, which could lead to it being used as a protection for health care workers and other susceptible individuals.

1.4.2 Poliovirus vaccine

Poliovirus (wildtype 1, 2 and 3) is a highly contagious virus transmitted with faecal-oral contamination which primarily affects children (28). It can cause asymptomatic infections, aseptic meningitis, and poliomyelitis. In poliomyelitis, motor neurons are destroyed, which can lead to paralysis and death if it causes respiratory muscle dysfunction. Most infections are asymptomatic, and poliomyelitis occurs in only 1% of cases (29).

There are two vaccines against polio: inactivated poliovirus vaccine (IPV) and live attenuated oral poliovirus vaccine (OPV). In low-income countries, WHO recommends giving OPV at birth, 6, 10 and 14 weeks and one dose of IPV after 14 weeks. It is recommended that IPV is given after OPV to boost immunity to poliovirus 1 and 3 and provide partial protection against serotype 2 (30). In most high- and middle- income countries, WHO recommends three or four doses of IPV, depending on which age they are given. OPV is preferred in low-income countries because it is less expensive than IPV, although it is not as safe (30).

In 1988, when the annual burden of poliomyelitis was more than 350,000 cases globally, it was decided at the World Health Assembly to eradicate the disease before 2000. The goal was not reached, but in 2018 reported cases had declined by 99% and were in total 33 cases (28). Wildtype 2 was eradicated in 1999, and Wildtype 3 has not been reported since 2012 (30). Although type 2 vaccine viruses, components from OPV are now a cause of poliomyelitis. It is mainly correlated to the first dose given at birth, and the probability decreases more than ten times by the second dose (30). In 2020, Pakistan, Afghanistan and Nigeria are classified as endemic, and on 28 April 2020, 46 cases of wildtype poliovirus 1 had been confirmed by WHO (31).

1.4.3 Pentavalent vaccine

The pentavalent vaccine or DTP-hepB-Hib protects against diphtheria, tetanus, pertussis, Hepatitis B and *Haemophilus influenzae* type B.

1.4.3.1 Diphtheria, tetanus and pertussis vaccine

Diphtheria is caused by the exotoxin forming bacteria *Corynebacterium diptheriae* and is transmitted with airborne droplets or by physical contact. The infection can either be respiratory or cutaneous. A respiratory infection is characterised by a pseudo-membrane which often forms at the pharynx. If it reaches the bloodstream, the exotoxins can cause damage to organs such as the peripheral nerves, heart and kidneys (32).

Tetanus is a neurological disease caused by tetanus toxin, formed by the bacteria *Clostridium tetani*. Spores of the bacteria are commonly found in soil or animal faeces and can transmit to wounds. From there, it can spread to the nervous system and caused increased muscle tone and severe muscle spasms which can lead to death (21).

Pertussis or whooping cough is a highly contagious, respiratory disease caused by the bacteria *Bordatella pertussis* and spreads with respiratory droplets. Bursts of non-productive cough are characteristic for the infection and can cause hypoxia. The infection can also be asymptomatic or cause mild respiratory illness, such as cold and fever (21). The incidence of pertussis is highest among infants, and that age group has as well the highest mortality rate (32).

Diphtheria-toxoid containing vaccines are among the oldest vaccines in use. Since the 1940s it has been combined with vaccines against tetanus and pertussis (DTP). The vaccine should be administered in three doses, starting at six weeks old, with a minimum of four weeks between doses (32). DTP is often used as a monitor for vaccination coverage and immunisation services, i.e. the percentage gap between the third and first dose given. As mentioned earlier, globally, the immunisation coverage for DTP was 86% which is similar to recent years (33).

1.4.3.2 Hepatitis B vaccine

Hepatitis B virus (HBV) is transmitted by blood-to-blood contact and transmission can occur perinatally (from mother to child during birth), with sexual contact or blood transfusion. HBV primarily infects hepatocytes, and the infection can be asymptomatic, acute or chronic hepatitis, which can lead to cancer and cirrhosis (34). In highly endemic areas transmission is most abundant perinatally. Those infected when they are young are most likely to develop a chronic disease, 80-90% of infected infants develop chronic hepatitis but only 5% of infected healthy adults (35).

There has been a vaccine against hepatitis B (hepB) obtainable since 1982 (34). WHO recommends that all infants are immunised with three doses of hepB, where the first dose is given at birth and the second and third simultaneously with DTP (35).

In 2015, approximately 257 million people were living with chronic hepatitis B, but only 9% of them knew their diagnosis, and 887,000 died from it (36). It is estimated that 6.1% of the population in Africa lives with hepatitis B, which is among the highest rates by WHO region (35). In 2015 the global coverage for HepB vaccination was 84%, but only 39% for the initial birth dose (36). SDG Target 3.3 aims at reaching 90% coverage before 2030, which is a part of a strategy to eliminate viral hepatitis as a public health threat (37).

1.4.3.3 Haemophilus influenzae B vaccine

Haemophilus influenzae type B (Hib) is a bacteria transmitted with airborne droplets which colonises in the nasopharynx (38). Approximately 20% of infants are colonised, and more than half of children U5 (39). Most of those infected are asymptomatic, but Hib can invade the bloodstream and cause meningitis, pneumonia, otitis media, sinusitis and other diseases (38). Before the introduction of the Hib vaccine, it was the leading cause of meningitis in children between the age of 6 months and three years old (21). Hib vaccines have been available since the 1990s and are considered as a highly effective public health intervention (38). Use of the vaccine has resulted in more than 90% contraction in cases of invasive Hib in countries that have included it in their immunisation program, and nasopharyngeal

colonisation has decreased in areas where coverage is high (38). The vaccine can be given either monovalent or with other vaccinations, such as DTP (38). In 2018 the global coverage for Hib was 72% which is 80% increase since 2010 (16).

1.4.4 Pneumococcal conjugate vaccine

Pneumococcal infections caused by *Streptococcus pneumoniae* are frequent in children and transmit with respiratory droplets leading to a colonisation in the nasopharynx (40). It is the leading cause of bacterial pneumonia, sepsis and meningitis in children, but can also spread from the nasopharynx and cause otitis media and sinusitis (40, 41). As for Hib, asymptomatic carriage is common, and it is estimated that 20% to 60% of school-age children are colonised (42). HIV and other immunosuppressive diseases increase the risk of getting pneumococcal pneumonia (40). If *S. pneumoniae* reaches the bloodstream, causing bacteraemia, the infection is classified as invasive pneumococcal disease (40).

In 2015, approximately 9.2 million children, from 1-59 months old, worldwide were diagnosed with pneumococcus, and 318,000 children died, thereof 166,000 in Africa. Globally approximately 294,000 HIV uninfected children died, which is a 50% decline since 2000 (43).

In 2009, two new vaccines, 10-valent pneumococcal vaccine (PCV-10) and 13-valent pneumococcal vaccine (PCV-13) were put on the market. Previously a 7-valent vaccine had been available. WHO recommends PCV-10 and PCV-13 for prevention of invasive pneumococcal disease, acute otitis media and pneumonia caused by *S. pneumoniae.* Three doses should be given with at least four weeks interval, starting at six weeks old with a booster dose six months after the third dose (40). In 2018, the global coverage for PCV was 47%, and it was estimated that the vaccine prevented 250,000 deaths between 2000 and 2015 (43). Other vaccines containing 10-20 serotypes are now in trials (40).

1.4.5 Rotavirus vaccine

Rotavirus is the most common cause of acute gastroenteritis in children globally and a leading cause of dehydrating diarrhoea in children U5 (44). It spreads with faecal-oral transmission and symptoms can range from loose stools to severe diarrhoea and vomiting, which can cause dehydration and electrolyte imbalance (45). The virus affects almost all children from three to five years old. Neonatal infections also occur, but often are asymptomatic. Repeated infections are prevalent, but symptoms are lesser and often asymptomatic in adults (46). In 2016, rotavirus caused approximately 128,500 deaths among children under 5 (U5) years of age which is a 48.2% decline since 1990 (47).

Two rotavirus vaccines are licensed, Rotateq (RV5) and Rotarix (RV1) which are both live, oral, attenuated vaccines and have been available since 2006 (45, 46). In 2009, WHO recommended that all countries should include rotavirus vaccination in its immunisation programs (48). It is recommended that RV5 is administered in three oral doses at two, four and six months old and RV1 at the age of two and four months (45). Studies have shown an increased risk of intussusception after administration of RV1 and RV5 (49, 50). In 2019, two meta-analyses of placebo-controlled randomised trials showed that the

vaccination was not associated with higher risk of adverse effects, which displays that the risk of intussusception is lower in vaccinated children than the risk of acute gastroenteritis in unvaccinated children (51, 52). In 2016, it was estimated that the vaccines prevented 282,800 deaths of U5 year old children globally and approximately 85% of those children lived in SSA (46).

1.4.6 Measles-rubella vaccine

Measles-rubella (MR) vaccine consists of vaccine components for measles and rubella and is made from a live-attenuated virus (53). Measles is a highly contagious virus which spreads through nasopharyngeal secretions by air or direct contact. It can cause high fever, conjunctivitis, rhinitis, and rashes. The measles virus can likewise disseminate to other organs and cause major complications, such as pneumonia, myocarditis and encephalitis, which can lead to death (21).

The measles vaccine has been a significant contributor to lowering U5MR. Before it was adopted in 1960 measles were the leading global cause of morbidity and mortality in children U5 (54). Since then, deaths have declined substantially. From 2000-2018 was a 73% reduction in deaths from measles, and it is estimated that the vaccine prevented 23.2 million deaths. Still, it caused over 140,000 deaths in 2018, mostly in U5 children (55). Despite a decline in cases, there has been a set-back. Globally the incidence doubled from 2018-2019 (33).

For long, it has been a goal to eradicate measles. In 2002 measles were eliminated in South and North America which proofed that the virus could be eliminated. Although outbreaks have occurred in the region again, which shows that countries that have eliminated measles are still susceptible to the virus while it has not been eradicated (54, 56). In 2018, 82 countries had eliminated measles, although there was an outbreak in all WHO regions (33). Globally, the coverage for the first dose was 86% and 69% for the second dose, which has risen from 42% in 2010 (33). Because of how contagious measles are, coverage needs to be a minimum of 95% with two doses of measles vaccination which shows that the world will need further coverage to eradicate measles (56). According to WHO all susceptible children and adults who are not with contraindications should be immunised with two doses of measles vaccine. Where incidence and mortality from measles is high children should be immunised at nine months but where the coverage is higher the first dose can be given at 12-15 months. The second dose should be given in the second year at least four weeks after the first dose (53).

Rubella is not as infectious as measles, and only one dose is required for immunity (33). The virus is airborne like measles and can cause a rash or be asymptomatic (57). Complications are rare, but it can cause encephalitis and congenital rubella syndrome (hearing loss accompanied by mental retardation, cardiac and ocular defects) (58).

1.4.7 Malaria

Malaria is a disease caused by a sporozoite, most often *Plasmodium falciparum* which is carried between humans by an infected female anopheles' mosquito. After an infected mosquito bite, the sporozoites replicate in the liver and create merozoites which later burst and invade erythrocytes causing a red blood cell lysis (21). During the incubation time, while the pathogen is still in the liver, the individual is asymptomatic. However, when it has reached the bloodstream, it can cause periodic episodes of chills, fever and sweating and later altered consciousness, severe anaemia, respiratory distress, shock, hypoglycaemia and acidosis which can lead to death (21, 59). Children from two to five years old and pregnant women in endemic areas are in most risk of developing the disease. With time children and adults develop natural immunity which makes them less susceptible to getting severe malaria (60).

In 2018, approximately 228 million cases of malaria occurred globally, and 93% of them were in Africa. It was estimated that approximately 405,000 died from the disease, comparing to 585,000 in 2010. U5 children are most at risk, and in 2018, 67% of deaths occurred in that age group (61). In 2015, WHO released Global Technical Strategy for malaria with the goals to reduce malaria mortality and incidence rates globally by 90% in 2030. The ultimate goal is to free the world of malaria. Universal access to malaria prevention, such as with long-lasting insecticide nets, indoor residual spraying and medication, diagnosis and treatment is vital to reach the goals (62). WHO recommends preventive medication against malaria for pregnant women and infants and season chemoprevention for children U5, where malaria transmission is moderate to high (63). There is not a licensed vaccine for malaria, but several candidates are in development (64). RTS S/AS01 is the only one that has completed phase III clinical trial. It has gotten positive assessment from WHO but there are still uncertainties that need to be resolved before the immunisation will be recommended for routine use (64).

1.4.8 Cold chain

Vaccines are temperature-sensitive biological products. All vaccines have certain storing requirements; some are sensitive to freezing or heat and some to light. If a vaccine is stored at an inappropriate temperature, it can diminish its potency, which cannot be regained (65). Immunisation supply chains comprise activities, tools, resources and planning necessary to ensure that vaccines stay at the right temperature and thus are safe, effective, and able to reach all in need. The supply chains are equipped with cold chain equipment (CCE) to keep the vaccines at the right temperature, 2-8°C (65, 66). At health facilities, refrigerators, should be used to store vaccines and cold boxes (insulated containers which can be lined with ice packs) should be used for transportation or short-term storage, for example, if there is no electricity. Vaccine carriers are smaller than cold boxes; they are also used for transportation, such as to outreach clinics (65). Refrigerators can be powered with electricity, gas, kerosene or solar energy (65). CCE provides greater access to immunisation and greater vaccine safety and potency. Consequently, it contributes to improved immunisation coverage and equity and is considered critical in closing the immunisation gap (67, 68)

1.5 Malnutrition

Malnutrition can be caused by deficiency, unstable, or excess intake of energy and/or nutrients. It can appear as undernutrition, micronutrient related malnutrition (micronutrient deficiency or excess) or either as overweight or obesity (69). Undernutrition or protein-energy malnutrition is when the body gets an insufficient amount of macronutrients; carbohydrates, fats and proteins (3). It is a factor which contributes to approximately 45% of death among children U5 years old; most of those deaths are in low- and middle-income countries. Children do not die of malnutrition alone, but it can contribute to a child's death by making them more susceptible to infectious diseases that, in general, are not fatal to well-nourished individuals. Undernutrition is classified as stunting, wasting or underweight (69).

Stunting means that a child is too short for its age. It is a marker that children are not developing well, both physically and mentally. It can lead to learning difficulties and poor health and therefore poverty (70). Stunting can begin in utero, and it has been shown that it is most serious in the first two years of life. Mothers who suffered stunting in childhood are at greater risk of having stunted children. Undernutrition can, therefore, be interwoven across generations and transmit poverty from one generation to another (70). It has been shown that stunting prevalence among children U5 years old decreases as wealth increases (71). Risk factors for stunting are fetal growth restrictions, preterm birth, environmental factors, such as unimproved hygiene, maternal nutrition and infections, the child's nutrition and infections, short birth intervals and teenage motherhood (72). Repeated infections, such as enteric, can trap a child in a dangerous cycle. They make it harder for the child to absorb nutrients and thus weaken its immune system (70).

While stunting can reflect a child's nutritional status over a long time, wasting reflects on a recent loss of weight arising from severely inadequate nutrient intake, illness, or both. It means that the child is too thin for its age and can both cause severe growth impairment and delayed psychological development. The prevalence of wasting in population is considered a good measure of acute undernutrition (3, 70). Prevalence can alter rapidly, adjacent to the seasonal availability of food and disease patterns for diarrhoea and malaria. As stunting, wasting can be linked to poverty. It can cause severe acute malnutrition which often is a result of rapid deterioration in nutritional status and children show signs of wasting, thinness and swelling (caused by inefficient uptake of proteins). If severe acute malnutrition is left untreated, children are twelve times more likely to die than a healthy child (70).

Underweight is when children are too light for their age. Underweight children can either be wasted, stunted or both (69).

Globally the proportion of stunted children has been declining. However, major country and regional differences exist. Most of stunted children live Sub Saharan Africa and South-East Asia where one out of three children under five is stunted, and despite a decline globally there was an increase in Sub-Saharan Africa between 2000 and 2018 which has been linked to strong population growth (70). Despite the decrease in stunting the world is not on track to reach the SDG targets for malnutrition in children U5, i.e. 12.2% for stunting and 3% for wasting. In 2018, 22% of children U5 were stunted, and 7.3% suffered from wasting (70). Preventive measures, such as nutritious interventions, family planning,

education, water supply, hygiene and sanitation, are essential in reaching the targets because stunting is not treatable (73, 74).

1.5.1 Growth monitoring

Growth monitoring is an activity where children are weighted and measured. It may be done privately in a health centre or at a public place outside, which is common in low-income countries (3). There it is used as a screening procedure where health care workers monitor growth to identify children with evidence of malnutrition and assist them (75). A Hanging scale which often is hung in a tree, is used to weigh the children. A health care worker reads off the scale and registers the information on a growth chart which is used to classify a child's weight-for-age (3, 76). The direction of the child's line in the chart is emphasised. It is good if it is parallel to the reference line, can be an early warning if it is flat and indicate overnutrition or obesity if it is above the line. A falling line is a danger sign (76). Middle-upper arm circumference measurement can also be done for further evaluation. It is a more reliable measure to predict mortality than weight for height and thus to plan nutritional interventions (3, 75). If growth is abnormal, appropriate investigations are performed and can lead to an illness being diagnosed. Growth monitoring can be used as a part of health education where guardians are informed about feeding, hygiene, and other essential factors to keep their children healthy. It is often also a part of immunisation activities, supplementary feeding activities, family planning and general monitoring of family health (3, 75).

Beneficence of growth monitoring has been disputed. It has been hard to find unequivocal evidence that it confers a benefit because the effect of other inputs cannot be disaggregated (76). Lack of clarity and purpose are components in the debate about the efficacy of growth monitoring. Also, a large amount of valuable health workers' time is spent in executing growth monitoring sessions (77). On the other side, it is linked to a reduction in children's undernutrition, morbidity and mortality (76). It helps to diagnose growth faltering, and it increases guardians awareness of their children's health and factors that can affect it. Proper nutritious counselling is supreme for growth promotion. It is important to offer health- and nutritional interventions adjacent to growth monitoring to reduce child malnutrition and mortality (76). Where coverage is low, and there are little improvements, it could be more useful to emphasise on growth promotion activities. It has also been shown that it should prioritise children from 0–18 months. Infants should be targeted, and if there is growth faltering, they should be monitored until 18 months (76).

1.5.2 Vitamin A Deficiency

Globally Vitamin A deficiency is the leading cause of preventable blindness in children (78). It affects about 190 million preschool-age children with the highest rates in Sub-Saharan Africa and South-East Asia, where nearly half of children aged 6 – 59 months old are affected (79, 80). Often the earliest sign of vitamin A deficiency is night blindness. Because vitamin A is an important factor in supporting growth and the immune system in children, it can cause morbidity and mortality from measles, diarrhoea and

respiratory infections (3). In 2013 vitamin A deficiency contributed to 18.4% of deaths attributable to diarrhoea and 13% of deaths attributable to measles in Sub-Saharan Africa (81).

WHO recommends giving vitamin A supplementation in settings where vitamin A is a public health problem, twice a year to infants and children 6–59 months old and to pregnant women (79, 82). It is not recommended for newborns, infants under six months old, HIV positive pregnant women and postpartum women (83-86). It is often distributed among immunisation activities or other health interventions such as deworming and nutrition counselling (3).

2 Aim of the study

The over-all aim of the study was to identify and describe potential problems in preventive child health services in a low-income SSA setting, assess the trends in vaccination coverage and explore how the services could be improved.

The study was conducted in Mangochi District, Malawi and had the following specific objectives:

1. Outline and describe preventive child health services, focusing on immunisation, growth monitoring and vitamin A supplementation
2. Examine trends in vaccination coverage between 2015 and 2019 in Mangochi District
3. Review and analyse flow of children before and after the inauguration of the new maternity wing
4. State and discuss main problems for preventive child health services
5. Appraise quality of preventive child health services by focusing on immunisation services

3 Materials and Methods

3.1 Malawi – The setting

Malawi is a country in south-eastern Africa. It is bordered by Tanzania, Mozambique and Zambia. Malawi's most prominent landmark is Lake Malawi which covers about a third of the country. In 2019, the total population was estimated 18.6 million and the surface area is 118,484 km^2 which is similar to the size of Iceland (87, 88). The population density is 197.6 per km^2, comparing that the population density in Iceland is 3.4 per km^2 (87, 88). Most of the people lives in rural areas (83%), and the majority depends on agriculture which makes them sensitive to crop failure (87). Malawi is one of the poorest countries in the world, with GDP per capita 340$ (87). In 2019 it was ranked number 172 out of 189 countries at the Human Development Index with the value 0.49 (5). The country has a rapidly increasing population. In 2018 the population growth rate was 2.8%, and the total population was almost four times the size in 1966 (89). The population is growing, although the fertility rate is decreasing. Life expectancy at birth has gone up. It was 45 years in 2000 comparing to 64 years in 2019 (5, 90). In 2000 the fertility rate was six births per woman comparing to 4.2 in 2018 (87, 89). The main causes for Disability Adjusted Life Years (DALYs) are HIV/ AIDS, maternal and neonatal disorders, respiratory infections, including TB, and malaria amongst other neglected tropical diseases (2). Further information regarding socio-economic and health indicators are in Appendix 1.

3.1.1 Structure of health care in Malawi

In Malawi, health services are divided into a private and a public sector. Services at the private sector are both for profit and not for profit.

3.1.1.1 Private sector

The private for profit (PFP) sector comprises private hospitals, clinics and traditional healers. The private not for profit (PFNP) sector consists of, non-governmental organisations, religious institutions, statutory corporations and companies (91). Christian Health Association of Malawi (CHAM) is the main religious provider in the country and the largest non-governmental health care provider. The organisation runs 179 health facilities and 11 training colleges, which are predominantly situated in rural areas (92). Most of the PFPs and PFNPs charge user fees (91).

3.1.1.2 Public sector

Public services which are free of charge are provided by governmental departments. They are organized into three tiers: primary, secondary and tertiary levels. The primary level consists of community hospitals, health centres and health posts. Primary level services include door-to-door visitations, static and outreach clinics where promotive and preventive health care services are provided. Health centres are meant to serve approximately 10,000 people (91). They offer outpatient and maternity services. Community hospital offer outpatient and inpatient services. They are larger than health centres. At the secondary level are district hospitals which are 26 in the country. Primary facilities can

refer people to them. The district hospitals are bigger than the community hospitals and adjacent to offering both outpatient and inpatient services they provide as well surgical procedures. At the tertiary level are four central hospitals. They should provide advanced specialised care, although 70% of the services offered are primary or secondary services (91). District hospitals can refer patients to central hospitals (91).

3.1.1.3 District health care workforce

District hospitals in Malawi are staffed with a few doctors. Beside them work clinical officers and medical assistants. Clinical officers are an essential part of the staff at the health centres along with nurses and midwives who provide primary maternal and child health services. At the district hospitals is a district health management team (DHMT) which includes clinical, administrative, nursing, and environmental arms. The DHMT plans, supervises, and appraises the health care services provided in the district (91).

Community health workers work at the primary level, including Health Surveillance Assistants (HSAs) and Community Health Volunteers. HSAs are the main connection between the formal health system and the rural communities. They provide health promotion and preventive interventions such as immunisation and growth monitoring. They are as well trained to recognize vital clinical signs and can advise guardians to seek further help at next level of the health care system; yet HSAs have inconsistent and unclear responsibilities (91, 93). They have 12 weeks pre-service training which does not provide them with the skills that are expected to deliver various services efficiently (94). Community health volunteers work with the communities they live in to improve their health status. They are unpaid volunteers that receive no formal training and are selected by community members (93, 95)

3.1.2 Human Resources

An essential component to reaching universal health coverage is a health workforce that is well trained, with sufficient numbers and distributed equally. In Malawi is a persistent gap in human resources capacity within the public sector. Health workers to patient densities are 0.02 physicians and 0.2 nursing and midwifery personnel per 1,000 population (96). According to WHO the country needs at least 4.5 professional health workers per 1,000 inhabitants to realize the SDGs (97). Improvements have been observed in recent years, although the size of the workforce has not been increasing in accordance with the population growth (96). Besides the increasing demands from a growing and ageing population, there is insufficient training and recruitment, and health workers are distributed unevenly (98). Vacancy rates are up to five times higher in rural areas than in urban areas (98). Emigration of health workers outside Malawi is also a significant cause of health care workers shortage. There is an excessive workload and poor remuneration adjacent to difficult living and working conditions (98). Besides a shortage of physicians, midwifery and nursing personnel, there is a shortage of community-level workers in Malawi, especially HSAs. There is a policy recommendation of 1 HSA to 1,000 population which the country is over 7,000 positional values short of meeting (94). They are distributed unevenly across the

districts seeing that only half of the HSAs reserve in their catchment area, which affects services in rural areas (94).

3.1.3 Mangochi

Mangochi is one out of 28 districts, situated in Southern Malawi. The district's population was estimated at 1.2 million in 2018 (89). The areas primary issues are high population growth rate (Mangochi has one of the highest population growth rates in Malawi), food and nutrition insecurity and high maternal deaths, children mortality and morbidity. It is divided into five zones/ health areas: Chilipa, Boma, Monkey Bay, Makanjira and Namwera. There are 43 health facilities in the district, 25 of them are government-owned, and 18 are privately owned (99). Most of the private facilities are owned by CHAM. Mangochi District Hospital is run by the government and is situated in Mangochi Town. It provides primary level health care to the surrounding community, approximately 80,000 people, and secondary health care to the entire district. In 2015 worked three doctors (out of five in the district), six medical assistants, 19 clinical officers, 77 nurses and 54 HSAs at MDH (99). In January 2019, was inaugurated a new maternity wing at the hospital which the Embassy of Iceland in Lilongwe constructed (100). The Embassy (then Icelandic International Development Agency (ICEIDA)) has been involved in development assistance with Malawi since 1989. The partnership began with activities related to fisheries in Lake Malawi and has been gradually extended to health, primary education, adult literacy, water, and sanitation. One of the Embassy's significant projects was the construction of a community hospital in Monkey Bay, which was handed over to Malawian authorities in 2011 (101). Since 2012 the cooperation has expanded to cover the entire district. The current program support aims to strengthen basic services in the district with particular emphasis on supporting Malawian authorities in achieving the SDGs (102).

3.2 Methods

3.2.1 Data collection

The author collected data in Mangochi District in the period 26 February 2020 to 17 March 2020, both quantitative and qualitative data. Qualitative data was collected with participatory observation to observe and monitor the U5 clinic's operation, and by conducting five semi-structured interviews with HSAs at the static clinic. Prior to interviews, informed consent was obtained. Answers were written on a computer concomitantly as they were conducted. All interviews were conducted in English. The questionnaire is in Appendix 2.

Quantitative data was conducted by collecting data from District Vaccine Data Management Tool (DVDMT) and "Under 2 Years Children Register" at the static U5 clinic. Baseline data on vaccinations in Mangochi District from 2015–2019 was obtained from DVDMT. The following variables were extracted from the database: Total population, pregnant women, live births, surviving infants, number of health facilities, completeness, timeliness, static sessions conducted, static sessions cancelled, outreach

sessions conducted, outreach sessions cancelled, fully vaccinated children (FVC), and number of vaccinations for BCG, OPV0 - OPV3; IPV, Penta1 - Penta3, PCV1 – PCV3, Rota1, Rota2, MR1 and MR2. Similarly, the number of vaccinations administered at MDH from 2015-2019 was also collected from the database.

The number of children attending immunisation daily and vaccines they were provided with at the static U5 clinic were collected from registrations in “Under 2 Years Children Register” book over seven days during the period, because it was only used in those days. For each child were subsequent variables extracted: registration day, date of birth, monthly serial number, sex and which vaccinations were given (BCG, OPV0 - OPV3; IPV, Penta1 - Penta3, PCV1 – PCV3, Rota1, Rota2, MR1 and MR2)

An experiment on for how long guardians must wait to get immunisation services was conducted 16 and 17 March. Notes were numbered and handed out to guardians, that were bringing their children for vaccination, in the line at the growth monitoring station. The notes were collected in the vaccination room when the child was vaccinated. It was registered at what time they were handed out and when they were retrieved.

3.2.2 Data Management and analysis

The qualitative interviews were analysed with the grounded theory approach to break down the data and categorize it (103). The programs Excel and R Studio were used for statistical analysis. Number of surviving infants in 2015 was calculate by using the same proportion (84% of live births) as was used for 2016-2019. Coverage was calculated for all vaccinations (Appendix 3). For the coverage in the district, projected population for live births was used to calculate the coverage for BCG and OPV0 and projected population for surviving infants for the other vaccinations. Drop-out rate for penta1–penta3, penta1–MR1 and BCG–MR2 and MR1-MR2 and under- and unimmunised for penta and MR vaccinations was also calculated. Analysis of variance (ANOVA) was executed to compare means of coverage rates and drop-out. Coverage at MDH was calculated with projected population for children under one years of age for all the vaccinations.

Total vaccinations and visits each day, how many inoculations each child got and age of children attending the static clinic was calculated. The age was compared with what immunisation they were provided at the session to estimate if they were immunised at the right time (margin of error: ±2 weeks).

3.3 Consent

The study was approved by the Mangochi Health Research Committee on 25 February 2020.

4 Results

4.1 Participatory observation

4.1.1 Under-five clinic at Mangochi District Hospital

The Under-five (U5) clinic is one of the departments at the new maternal wing. Services provided at the clinic are: Growth monitoring, immunisation, HIV testing and health services for children. The U5 clinic consists both of a static clinic and outreach clinics. The static clinic is at the hospital, and people who live near it can visit it, and is open all working days. Outreach services are conducted in villages based on a fixed monthly schedule. The aim of providing them is to bring health care services closer to the community.

4.1.2 Growth monitoring

Every child that comes to the U5 clinic is weighted. Growth monitoring is performed under a tree outside the static clinic. A Hanging scale is used to weigh children under one years of age (see figure 1). Guardians hang their infants in a *chitenje* (a shawl that they use to carry their children in) onto the scale and an HSA reads it and registers the weight in the child's health profile. Before the infants are weighed, guardians are supposed to unclothe them, except the napkin and underpants. A floor scale is used to weigh children older than one year of age. They do not have to undress, but they must take off their shoes. Every morning guardians line up with their children outside the clinic before it opens. Before a session begins, the Hanging scale is zeroed with a *chitenje*. After the children are weighted, they either go to see a physician or get a vaccination.

Figure 1. Child weighted with a Hanging scale. Photo by author

4.1.3 Immunisation

At the static U5 clinic, immunisation services are provided for children and women at childbearing age. Inside it is a room where vaccinations take place. There are benches that guardians and women can sit on while they wait for them or their child to get an immunisation. Inside the room is as well a refrigerator where vaccines are stored. Two HSAs take part in the session; one handles registration and the other vaccines. The guardian shows an HSA its child's health profile where she/he can see what vaccination should be provided. Inoculations that are given are registered in the child's health profile. They are as well recorded in a registration book ("Under 2 Years Children Register") and summary book ("Immunization Tally sheet"). Every morning an HSA goes from the U5 clinic to the postnatal department to give BCG and OPV vaccinations. In the beginning of the session, the HSA educates the guardians.

He tells them the importance of immunisation and describes the vaccines. After that, vaccines are given and registered in the child's health profile. The aim is to reach every child.

4.1.3.1 Cold chain

There is a national store for vaccines in Lilongwe, a regional store in Blantyre and a store for Mangochi District at MDH. Once a month, vaccines are collected from the regional store and brought to the district store. There they are stored in refrigerators. Likewise, vaccines are restocked at the maternity wing and other health facilities once a month, transported in cold boxes from MDH. Immunisations are carried to outreach clinics in vaccine carriers from the U5 clinic every time a session is conducted.

Different energy sources are used for cold chain in the district. MDH uses electricity; meanwhile, the district uses solar-driven and gas driven refrigerators as well. If there is a problem at a health facility, for example, with the power, all vaccines should be collected in vaccine carriers and brought to the nearest refrigerator, which is functional to avert damage. Also, vaccines can be sent back to the district vaccine store.

4.1.4 Vitamin A

Child Health Days campaigns are aimed to be conducted in Mangochi District where children U5 years old and postpartum women are supplemented with vitamin A, and the children are dewormed along with nutrition screening and micronutrient supplementation. The activity takes place over a week every six months. It aims to reach all health facilities, both static and outreach, in the district. As for the immunisation, the objective is to reach every child. Due to financial constriction, the campaign has failed to be held. The district is working on changing to a routine supplementation where vitamin A supplementation is combined with vaccination sessions and given to postpartum women eight weeks after they give birth.

4.1.5 Registration books

Two registration books are used in the vaccination room: “Under 2 Years Children Register” and “Immunization Tally sheet”. Every child vaccinated should be registered in the “Under 2 Years Children Register”. It should be used every day, but because of a shortage of staff, the HSAs do not have time to use it. Each child should also have one line in the whole book, so when it comes back later, it should be looked up and the same line used again for a correct registration. Instead it was only recorded which vaccines were given the registration day. In the “Under 2 Years Register” it is noted what day the child came, date of birth, and which immunisation was given. Tally sheets are also supposed to be used to count how many vaccines are provided each day. The district gathers information about immunisations from Tally sheets at each health facility.

4.1.6 Child Health Passport

Every child should own a child health passport. It contains immunisation history and status. It serves both as a reminder for guardians to return to a clinic for the next dose of vaccinations and for the health care workers to determine the infant's immunisation and vitamin A status. Information included in the Child Health Passport is an identification number, name of the infant, sex, date of birth, address, immunisation record which contains a date of every immunisation given, growth monitoring chart and date of vitamin A supplementation. Table 1 shows the immunisation schedule.

Table 1. Immunisation schedule

Age	Immunisation
At birth	BCG
0 – 14 days	OPV0
At 6 weeks	OPV1
	Rota1
	Penta1
	PCV1
1 month after 1st dose	OPV2
	Rota2
	Penta2
	PCV2
1 month after 2nd dose	OPV3
	Penta3
	PCV3
At 14 weeks	IPV
9 – 11 months	MR1
18 – 23 months	MR2

BCG: Bacillus Calmette-Guérin, OPV: Oral Poliovirus vaccine, IPV: Inactivated Poliovirus vaccine, Penta: Pentavalent vaccine, PCV: Pneumococcal conjugate vaccine, Rota: Rotavirus vaccine, MR: Measles-rubella vaccine, FVC: Fully vaccinated children, •: not applicable

4.1.7 Outreach clinics

The U5 clinic offers outreach services as well as static services at the clinic. Every working day HSAs are scheduled to visit an outreach clinic which are conducted in areas further from the hospital. Services provided are immunisation and growth monitoring. HSAs most often use bikes or walk to get there. They bring vaccines, Hanging scales and registration books from the static clinic. The sessions usually take place under a tree where guardians convene with their children. In the beginning of the session, an HSA educates the guardians. They sing together songs about health-related topics, and they are as well told when the next meeting is scheduled. After that, children are weighted, registered, and immunised. HSAs check if the children are growing normally and if they are at good health. If a child needs further

assistance HSAs advice the guardian to bring it to the static clinic for an additional examination. Community health workers assist HSAs at the outreach clinics. Two outreach clinics were visited, that is in the villages of Manayma and M'gundaphiri (see figure 2 and 3)

Figure 2. Outreach clinic Manayma. Photo by author

Figure 3. Outreach clinic, M'gundaphiri. Photo by author

4.2 Interviews with Health Surveillance Assistants

All the health care workers interviewed at the static clinic were HSAs. Of the five participants, four were female. The median age was 41 years (range 40–59 years old), and their median period of employment at the U5 clinic was 13 years (range 10–33 years). All the respondents stated that they like their work at MDH. One of them said it is because they get to save children and women's lives by providing them immunisation and inform mothers on how to care for their child. When asked about working conditions, the clinic's housing often came up. It was discussed that the new U5 clinic was more spacious than the old one where the vaccinations took place in a tent, but the lodgings were still too small. The vaccination room is not big enough, and growth monitoring takes place under a tree outside the clinic which makes it hard during the rainy season. It was also mentioned that working conditions were challenging due to how crowded the clinic can be because of children visiting to meet a clinical officer or a medical assistant. It makes the health care workers susceptible to contracting diseases. Soap and disinfectants are not available so HSAs cannot involve proper sanitation to take care of their health.

The participants also reported a shortage of staff. There should be ten working at the clinic every day but are usually eight or fewer. It was stated that the government should employ more staff and have more people trained, both HSAs and volunteers.

Transportation was as well brought up. Bicycles were once provided for HSAs to go to the outreach clinics, but now they must walk or pay for a bike ride themselves. As for the salary, participants said that they did sometimes not get their salary paid at the right time. It was mentioned that it could make them late for work because they did not afford to rent a bike. The HSA said it could as well be disturbing and it made them work inefficiently.

When asked about guidelines and protocols, not all participants understood the questions. Those who had used guidelines said that they had been used in school and that they addressed immunisation and growth monitoring but were not accessible at the U5 clinic.

The respondents found growth monitoring essential to see how children are growing. If a child is underweighted or malnourished, they can send it to a nutrition clinic to get supplements. Guardians bring their children to be weighted to see how they are growing and for immunisation, because they know the importance of growth monitoring. Two of the participants answered that guardians knew the importance of immunisation, and they had never seen one refuse to vaccinate their child. In contrast, the others reported that it rarely happens and if it does its due to misconception or negative attitude. With health education, they most often get to change their mind. When asked why fewer children were brought to the static clinic for their later doses of vaccination, participants said it was because they get the first doses at the postnatal department and then the others in the community. It was likewise pointed out that some mothers think that if their child is healthy they do not have to vaccinate them again and other guardians do not have time to bring their children to the clinic and decide to attend their business instead.

4.3 Mangochi district child immunisation coverage

The study included the projected population, 241,323 of all live births in Mangochi District between 2015 and 2019. Demographics of relevance for immunisation services are reviewed in Table 2. Over the five years, more than 3 million immunisation injections were provided in Mangochi District. Annually, on average 621,918 doses were administered (median 590,369; SD 77,683) (Table 3). Fewest were given in 2016 and most in 2019, a difference of 33%. This includes vaccination to children under two years of age. More static sessions (mean 202; median 203; SD 2) were conducted compared to an average of 70 outreach sessions (median 69; SD 3) weekly. The proportion of cancelled sessions, both static and outreach, rose from 2015-2017, but was not available for 2018 and 2019. The average proportion of cancelled outreach sessions was 72% higher than for static sessions over the period.

Table 2. Demographics for Mangochi District 2015-2019

Demographics of relevance for immunisation services. Source: DVDMT

	2015	2016	2017	2018	2019
Total population	1,017,070	1,053,585	1,091,666	1,131,378	1,053,595
Pregnant women	45,771	52,680	54,585	56,569	52,680
Live births	41,194	52,680	49,125	50,912	47,412
Surviving infants	38,448	44,252	45,850	47,518	44,251
Completeness (%)[a]	100	100	100	100	80
Timeliness (%)[b]	57	71	56	69	66
Static sessions	10,558	10,564	10,282	10,511	10,540
Static sessions cancelled (n (%))[c]	241 (2)	414 (3)	619 (6)	•	•
Outreach sessions	3,565	3,580	3,486	3,828	3,833
Outreach sessions cancelled (n (%))[c]	188 (5)	218 (6)	359 (9)	•	•

[a] Proportion of total reports on immunisation received
[b] Proportion of reports received timely (before 5th of the next month)
[c] Number of sessions cancelled (percentage of sessions cancelled)

Total number of vaccinations and vaccination coverage for each year are presented in Table 3 and drop-out rates, under- and unimmunised in Table 4. When years within the period are compared there is a decline in coverage in 2016 and 2017. Fully vaccinated children (FVC) was on average 87% (median 82%; SD 12%). It was highest in 2015 and lowest in 2017. The coverage rate for OPV0 was significantly lower than the coverage rate for BCG ($p=3.5*10^{-5}$) and OPV1 ($p=1.1*10^{-3}$) with 49% average coverage for OPV0 (median 60%; SD 8%), 95% for BCG (median 98%; SD 10%) and 105% for OPV1 (median 111%; SD; 11%). On average the coverage for penta3 was 9 percentage points lower than for penta1, with most difference in 2017 (15 percentage points) and least in 2019 (4 percentage points). The drop-out rate from penta1 to penta3 changed over the term as well. It was lowest in 2019 and highest in 2017. It was on average 9% (median 8%; SD 5%). In 2015 and 2019 no children were unimmunised against penta3, but in 2017, 19% of infants were unimmunised against penta3.

4.3.1 MR vaccination

Coverage, drop-out rate, under- and unimmunised for MR1 and MR2 are shown in tables 3 and 4. The coverage rate was significantly lower for MR2 than MR1 (p=0.01). The coverage rate for MR1 declined by 38% from 2015-2016 and rose again above 100% in 2019. On average, the coverage for MR1 vaccine was 91% (median: 89%; SD 13%) and it was twice as high as the average coverage rate for MR2 (mean 46%; median 54%; SD 28%) The coverage rate for MR2 rose from 2016-2019 by 32 percentage points. The average drop-out rate for MR1 to MR2 was on average 48% (median 34%; SD 30%); it was 33 percentage points higher than the average drop-out rate for penta1-MR1 (mean 15%; median 17%; SD 44%). No children were unimmunised against MR1 in 2015 and 2019, but in 2017 the rate was 22%

Table 3. Number of vaccinations and coverage at Mangochi District 2015-2019. Source: **DVDMT**

Vaccines (n (%))[a]	2015 (n (%))[a]	2016 (n (%))[a]	2017 (n (%))[a]	2018 (n (%))[a]	2019 (n (%))[a]
BCG	44,030 (107)	42,123 (80)	45,522 (93)	49,741 (98)	47,113 (99)
OPV0	22,468 (55)	20,446 (39)	21,804 (44)	25,893 (51)	27,197 (57)
OPV1	44,039 (115)	41,682 (94)	42,965 (94)	53,835 (113)	49,308 (111)
OPV2	42,792 (111)	38,786 (88)	38,944 (85)	47,667 (100)	46,799 (106)
OPV3	43,440 (113)	38,471 (87)	37,321 (81)	45,923 (97)	46,551 (105)
IPV	•	•	•	•	41,775 (94)
Penta1	45,922 (119)	42,279 (96)	44,283 (97)	51,050 (107)	49,692 (112)
Penta2	43,263 (113)	39,492 (89)	39,174 (85)	48,573 (102)	47,510 (107)
Penta3	42,730 (111)	38,092 (86)	37,160 (81)	46,844 (99)	47,905 (108)
PCV1	47,941 (125)	41,378 (94)	43,219 (94)	49,893 (105)	49,638 (112)
PCV2	42,582 (111)	38,088 (86)	39,521 (86)	53,015 (112)	47,026 (107)
PCV3	42,559 (111)	36,986 (84)	37,997 (83)	47,145 (99)	47,722 (108)
Rota1	42,684 (111)	38,856 (88)	40,701 (88)	48,777 (103)	51,258 (116)
Rota2	44,886 (117)	36,129 (82)	36,290 (79)	45,437 (96)	46,633 (105)
MR1	41,033 (107)	34,991 (79)	35,773 (78)	42,333 (89)	45,090 (102)
MR2	•	18,248 (41)	24,845 (54)	27,858 (59)	32,454 (73)
Total vaccinations	590,369	546,047	565,519	683,984	723,671
FVC	38,826 (101)	34,142 (77)	33,900 (74)	39,433 (83)	43,085 (97)

[a] Number of vaccinations (coverage)
BCG: Bacillus Calmette-Guérin, OPV: Oral Poliovirus vaccine, IPV: Inactivated Poliovirus vaccine, Penta: Pentavalent vaccine, PCV: Pneumococcal conjugate vaccine, Rota: Rotavirus vaccine, MR: Measles-rubella vaccine, FVC: Fully vaccinated children, •: not applicable

Table 4. Drop-out rates, under- and unimmunised in Mangochi District 2015-2019. Source: DVDMT

	Drop-out				Underimmunised		Unimmunised	
Year	Penta1-3	Penta1-MR1	BCG-MR2	MR1-MR2	Penta	MR	Penta3	MR1
2015	7%	11%	100%	100%	3,192	41,033	-11%	-7%
2016	10%	17%	57%	48%	4,187	16,743	14%	21%
2017	16%	19%	45%	31%	7,123	10,928	19%	22%
2018	8%	17%	44%	34%	4,206	14,475	1%	11%
2019	4%	9%	31%	28%	1,787	12,636	-8%	-2%

4.4 Mangochi District Hospital child immunisation coverage

Over the five years more than 280,000 vaccinations were given children in MDH and 45% of them were provided at outreach clinics (Table 5). Fewest were given in 2015 and most in 2017, with a 40% difference. Weekly, on average 589 vaccinations (median 558; SD 115) were given at the static clinic, which is 14% higher than was provided on average at the outreach clinics (mean 490; median 537; SD 152)

The trend for number of vaccinations at the static and outreach clinics changed during the period. In 2015–2017, more vaccines were given at the static clinic, but in 2018 and 2019 more was provided at the outreach clinics. BCG was administered 5.9 times more often at the static (mean 5,298; median 5,121 doses; SD 1,105) than the outreach clinics (mean 896; median 878; SD 296) and the coverage was on average 155% (median 151%; SD 22%).

The average coverage for penta1 (mean 104%; median 93%; SD 15%) and for penta3 (mean 120%; median 86%; SD 85%) were likewise above 100%.

The average coverage for MR1 was 67% (median 67%; SD 6%), 32 percentage points higher than the average coverage for MR2 (mean 35%; median 40% SD 24%). More was administered of MR2 at the outreach than the static clinic all the years it was provided.

Table 5. Number of vaccinations and coverage at the U5 clinic, Mangochi District Hospital 2015-2019. Source: DVDMT

Vaccines	2015 static | outreach (%)[a]	2016 static | outreach (%)[a]	2017 static | outreach (%)[a]	2018 static | outreach (%)[a]	2019 static | outreach (%)[a]
BCG	4,788 | 892 (151)	5,580 | 712 (162)	6,989 | 617 (188)	4,011 | 1,384 (129)	5,121 | 878 (143)
OPV0	4,053 | 561 (123)	4,614 | 370 (128)	5,445 | 326 (143)	3,703 | 695 (105)	4,667 | 521 (124)
OPV1	1,792 | 1,300 (82)	2,584 | 1,248 (98)	2,737 | 1,276 (99)	1,323 | 2,696 (96)	1,699 | 2,229 (94)
OPV2	1,652 | 1,429 (82)	2,097 | 1,899 (103)	2,140 | 1,496 (90)	1,014 | 2,715 (89)	1,369 | 2,230 (86)
OPV3	1,591 | 1,396 (79)	1,892 | 1,251 (81)	1,859 | 1,508 (84)	1,052 | 2,541 (86)	1,288 | 2,041 (80)
IPV	•	•	•	•	1,059 | 1,578 (63)
Penta1	1,933 | 1,473 (91)	2,382 | 1,242 (93)	3,047 | 2,040 (126)	1,380 | 2,924 (103)	1,642 | 2,118 (90)
Penta2	1,597 | 1,514 (83)	2,145 | 1,288 (88)	2,131 | 1,511 (90)	1,094 | 2,732 (91)	1,531 | 2,115 (87)
Penta3	1,539 | 1,342 (77)	1,903 | 1,125 (78)	1,745 | 9,242 (272)	1,022 | 2,856 (93)	1,514 | 2,074 (86)
PCV1	1,903 | 1341 (86)	2,406 | 1,239 (94)	2,451 | 1,510 (98)	1,296 | 2,714 (96)	1,652 | 2,152 (91)
PCV2	1,903 |1,467 (90)	2,031 | 1,226 (84)	2,007 | 1,577 (89)	1,240 | 2,800 (97)	1,350 | 2,099 (82)
PCV3	1,647 | 1,367 (80)	1,753 | 1,122 (74)	1,641 | 1,489 (78)	1,217 | 2,741 (95)	1,221 | 2,013 (77)
Rota1	1,914 | 1,352 (87)	2,068 | 1,170 (84)	2,325 | 1,603 (97)	1,345 | 2,526 (93)	1,602 | 2,043 (87)
Rota2	1,376 | 1,463 (75)	1,788 | 1,009 (72)	1,730 | 1,307 (75)	1,121 | 2,347 (83)	1,284 | 1,948 (77)
MR1	1,352 | 1,330 (71)	1,336 | 991 (60)	1,348 | 1,320 (66)	1,174 | 1,938 (74)	720 | 1,878 (62)
MR2	•	382 | 632 (26)	524 | 1,108 (40)	874 | 1,807 (64)	462 | 1,297 (42)
Total	29,040 | 18,227	34,961 | 16,524	38,119 | 27,930	22,866 | 35,416	28,181 | 29,214

[a] Number of vaccinations given at the static clinic | number of vaccinations given at the outreach clinics (coverage for both static and outreach clinics)
BCG: Bacillus Calmette-Guérin, OPV: Oral Poliovirus vaccine, IPV: Inactivated Poliovirus vaccine, Penta: Pentavalent vaccine, PCV: Pneumococcal conjugate vaccine, Rota: Rotavirus vaccine, MR: Measles-rubella vaccine, FVC: Fully vaccinated children, •: not applicable

4.5 Flow of children through the static U5 clinic

Table 6 presents total visits and total immunisation administered over the seven days data was collected. Ninety-seven children visited the U5 clinic for vaccination over the period. Out of them 49 (51%) were female. On average were 14 daily visits (median 11; SD 8). The youngest child visiting the clinic was one day old, and the oldest was two years and two months old. Children visiting were on average 18 weeks old (median 11 weeks; SD 18 weeks). In total, were 281 vaccines administered and on average 40 per day (median 25; SD 27).

Figure 4 shows the distribution of how many vaccines were given to children at the same time. Most of the children (70%) were given four vaccines, and 24% of them were not vaccinated at the visit. Thirty-five children, 50% of those who had birth registered, were immunised timely. Most of them were vaccinated too late while three were immunised too early.

Figure 5 shows how many doses were given of each vaccine. Most doses were given of PCV1 (16%). Over the period were given no doses of OPV0 and MR2.

Table 6. Total visits and vaccinations at the static U5 clinic Mangochi District Hospital

Registration date March 2020	Visits	Total vaccinations given
4	11	24
5	8	25
6	9	25
9	12	48
10	30	93
12	18	50
13	9	16

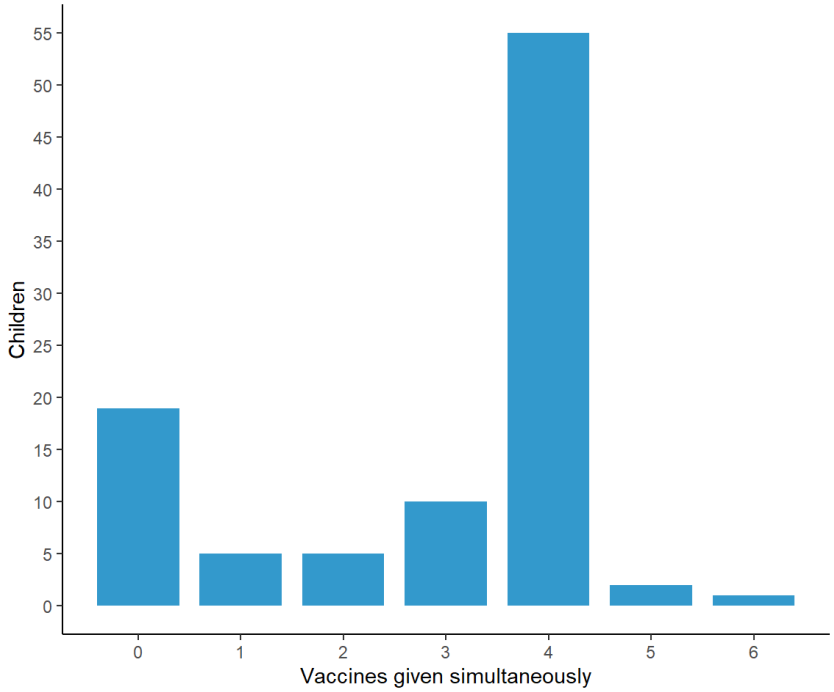

Figure 4. Vaccines given simultaneously at the static U5 clinic
Data collected from "Under 2 Registrations Book" at Mangochi District Hospital over a seven day period (4-6, 9, 10, 12, 13 March 2020)

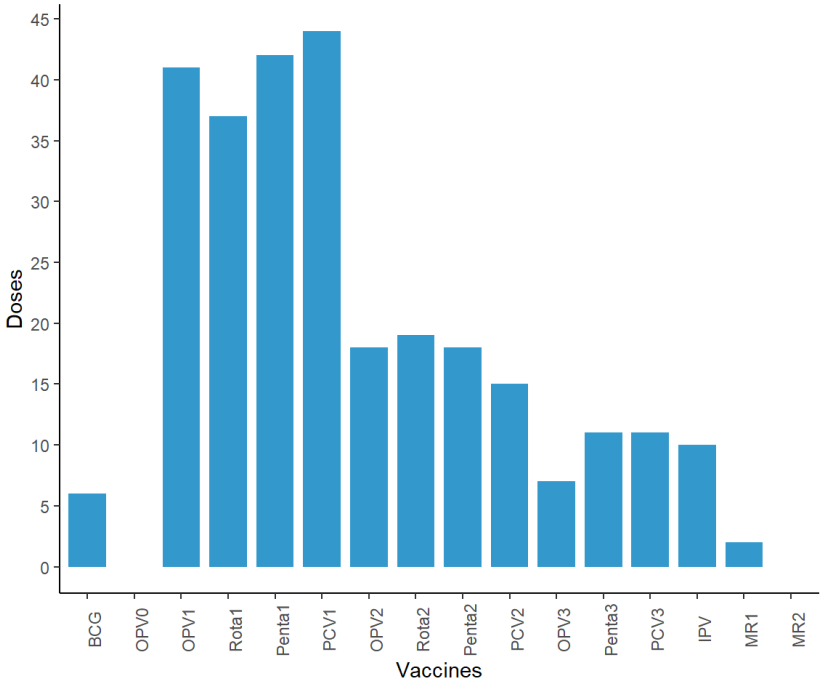

Figure 5. Number of doses given of each vaccine at the static U5 clinic
Data collected from "Under 2 Registrations Book" at Mangochi District Hospital over a seven day period (4-6, 9, 10, 12, 13 March 2020)

4.6 Waiting time

On a sign outside the U5 clinic, the average waiting time for caretakers in immunisation session was given to be 5-10 minutes. On the 16 March 2020, the average waiting was 58 minutes (median 58; SD 6) and 17 March it was 45 minutes (median 45; SD 6). Over these two days, the average waiting time was 53 minutes (median 53; SD 9). More notes to register waiting time were handed out than collected from caretakers upon leaving. On the 16 March, it was not known how many were handed out, but seven were handed back. On the 17 March, eight notes were handed out, but four were given back.

5 Discussion

This study describes and analyses preventive child health services, in particular immunisation, in a low-income SSA setting, here Mangochi District in southern Malawi. It builds on district data registered in DVDMT, as well as specific data on the services provided by the MDH. Further, it builds on interviews with staff in MDH, and participant observation. Despite over-all progress in immunisation coverage, the study identifies issues that may contribute to improve the vaccination services in the district.

5.1 Mangochi District child immunisation coverage

The study brings to light fluctuation in immunisation coverage rate with FVC decreasing by about one quarter in 2015 to 2016 to almost all being fully vaccinated in 2019. Cancellation of planned immunisation sessions in 2106-2017 may explain some of the fluctuations, resulting in lower coverage, in particular, outreach sessions. On average, cancellation of outreach sessions was 72% higher compared to static sessions. Reliable transport and support for HSAs and the other health professionals to conduct their planned sessions could contribute to more outreach sessions being conducted to improve the coverage rate.

Vaccination coverage can reflect utilisation and accessibility to health services in the area. Taking coverage of BCG as a reference point, to be given at birth and any time thereafter, the coverage rate for OPV0, to be given at birth, was significantly lower than for BCG ($p=3.5*10^{-5}$) (Table 3). Further, the study indicates that the coverage for immunisations administered later is lower than for those given earlier; this indicates that immunisation routines at birth, following skilled birth attendance, leave room for improvement. The high coverage for early doses indicate that immunisation services are accessible to a high proportion of children in the district and that the importance of vaccinations is recognized by the families (104).

The average rate of drop-out from penta1 to penta3 shows that on average one out of every ten children who receive penta1 were not vaccinated with the third dose; over-all, the drop-out rate was less than 10% in all the years except 2017 (Table 4). It indicates that the utilisation of the services was good and a proxy indicator on the quality of the services (104, 105). Many factors, such as socio-economic and demographic, can affect the coverage and drop-out rate. In this study, staff explained that some guardians did not think they had to bring their children again for later vaccinations if their child was healthy. Previous studies have shown that children born to mothers with higher level of education, who live near the health facilities, delivered at a health facility, or had a health profile for their child have higher immunisation coverage (106, 107). Also, first-born children are more likely to be fully immunised (106).

In addition to the indicator of FVC, measles vaccination is a sensitive indicator for the quality of immunisation services (64). In Malawi, MR is the only vaccination given after the first year, something that might change with the new malaria vaccine understudy in the country (108). Because of its high contagiousness, it is hard to eliminate measles, and the coverage needs to be 95% for the second dose of measles vaccine to reach herd immunity (56). The study showed that the coverage for MR2 was

significantly lower compared to MR1 (p=0.01) (Table 3). Compared with BCG vaccination coverage, the drop-out rate for MR2 was 55%, that is, more than half of the children who were vaccinated at birth with BCG were not immunised with the second dose of MR (Table 4). In 2015, the second dose of MR2 was not provided, negatively affecting the coverage. If the year 2015 is excluded, the average drop-out rate is 44%. The coverage rate for MR2 rose annually from 41% to 73% from 2016-2019 (Table 3), since MR2 was first administered in 2016, which shows that it has advanced faster than the coverage rate globally for MR2 (33). In 2015 and 2019, the coverage rate for MR1 was above 95%. It indicates that the district is on track to reach herd immunity and eliminate measles.

In both years 2015 and 2019, the rate for children not immunised against the first dose of MR and the third dose of penta was below 0%, which is another indicator for access to immunisation. Further, this indicates that there were more vaccinations administered than to be expected, based on population estimates. The reasons for such an outcome are manifold; in addition to wrong population estimate, people and visitors from other districts may also attend, thus boosting district coverage (Table 3). The rate was highest for both penta3 (19.0%), and MR1 (22%) in 2017 which shows that still not all children are reached (Table 4).

One reason for deficient coverage is cancellation of vaccination sessions. The highest proportion of cancelled sessions was in 2017, which could have contributed to lower coverage and higher proportion of children not being immunised (Table 2). It is essential that services are accessible for all children and that guardians know the importance of vaccinations. Previous study in Malawi, by Munthali et al., has shown that coverage was lower in rural than urban areas in Malawi (107). Coverage could be improved with more health care workers and with even distribution of them across the district.

Compared to Munthali's study, the immunisation coverage has risen in the district (107). In Malawi in 2004, the coverage for BCG, DTP3 and MR1 was 91%, 82% and 79%, respectively, compared to 99%, 108% and 102% in Mangochi District in 2019 (107). This is an indicator that services are now more accessible, and the utilisation of them is better. Since then, new vaccines have as well been added to the national immunisation program.

5.2 Mangochi District Hospital child immunisation coverage

The study showed that on average more vaccines were administered at the static clinic than the outreach clinics, although in 2018 and 2019, more was provided at the outreach clinics (Table 5). The number for vaccinations given in 2018 is probably higher, and thus the coverage, because two months of registrations were missing from the database. Missing values can cause fluctuations and thus weaken the quality of the data (109).

BCG was given 5.9 times more often at the static clinic than the outreach clinics, and the coverage was on average 155%, based on population estimate in the Boma health zone covered by MDH. The high coverage rate can be because it is a health facility with a maternity ward and is a referral hospital for all the district. Further, it indicates good utilisation of the facility, and women may come to MDH from other areas than Boma to give birth. The coverage for immunisations given at birth was calculated by

using the number of children under one year of age but not the number for live births as for the district. Because the number of infants is lower than the number of live births, it can cause the coverage to seem higher.

The study indicates wide variations in the number of vaccinations given in static compared to outreach clinics. Thus, in 2015–2017, static clinics administered more of penta1 than the outreach clinics, but vice versa in the period 2018-2019 (Table 5). On the other hand, more doses of MR1 and MR2 were administered in outreach clinics in the period 2016-2019. This shows that vaccinations that are provided at a later age are more likely to be given at outreach sessions compared to static clinics. This result highlights the importance of regularly conducting outreach clinics to obtain high immunisation coverage in the district.

5.3 Flow of children through the static U5 clinic

Part of the study was to examine the flow of children through the U5 clinic at MDH. When examining the data for the flow of children, on average, there were 14 visits per day (Table 4). The flow of children in 2019, is estimated at 39 children daily; this indicates that there were more visits over the seven day period, but they were not all registered. Flow of children in 2019 was calculated by dividing the total vaccinations given at the static clinic in 2019 (28,181 doses) with the average number of doses given per child over the period (3 doses) and number of working days.

Most of the children got four inoculations at the visit (Figure 4). According to guidelines, Penta, rota, PCV and OPV are given simultaneously. Yet, the numbers of doses given of those vaccines varied; for example, four more doses were given of PCV1 than rota1 (Figure 5). This may indicate that some vaccines might be out-of-stock at a particular session forcing guardians to bring their child again later to comply with the immunisation schedule.

Interestingly, about a quarter of the children visiting over the period were not vaccinated during the appointment. One reason might be incorrect registration. In the “Under 2 Years Children Register” there are lines that cover the centre spread in the book and information about each child should be written in one line. There were uneven lines at the right and the left page, which makes it both difficult to record in it and read it. That can likewise explain why only 50% of children were immunised timely, and three of them were immunised earlier than guidelines stipulate. Lack of quality of data registration could likewise explain why few children were registered at the clinic over the period. Observation of immunisation sessions at MDH indicate that the registration book was only used for seven days over the period 26 February 2020 to 17 March 2020, and it is possible the register was not used for all the children who visited the seven days that were specially analysed.

In these seven sessions in the vaccination room at MDH, few BCG doses were administered; no OPV0 was given because they are to be provided at the postnatal department, and consequently not recorded in the “Under 2 Years Children Register”.

Waiting times at vaccination sessions may impact the willingness of mothers/families to bring their children for vaccination. A study in Mozambique showed that accessing an antenatal care visit caused

both a financial and personal cost which are increased with long waiting time and can thus make the visit more challenging (110). At MDH, on average it took 53 minutes for the mother and/or caretaker to complete a visit for an immunisation session. This is to be compared to 5–10 minutes given up as waiting time at the clinic. The guardians arrive early outside the clinic each morning before it opens. Both days when this part of the study was conducted and the notes were handed out, many mothers had already lined up for growth monitoring. Due to language difficulties, it was not possible to ask them when they had turned up in the morning. Language barriers could as well explain why some notes were not handed back. Most guardians in the growth monitoring line outside the MDH were bringing their child to see a clinical officer or medical assistant and not for an immunisation. When handing out notes, it could be that some of the guardians who were not supposed to have one did get one, and some that were coming in for vaccination did not. This suggests that the waiting time might be even longer than the results indicate. This needs further study, as improving the flow of mothers and children through the different activities on offer might enhance vaccination uptake.

5.4 Strengths and weaknesses

The strengths of this study are that it covers all vaccinations administered at both the district and Mangochi District Hospital in a five years period. Further, both qualitative and quantitative methodologies were applied, which gives the study more scope and depth.

Despite the strengths of the study, there are some limitations. The first is that projected population had to be used to calculate coverage, drop-out rate and those not immunised. That is why the coverage rate can exceed above 100% and those not vaccinated below 0%. Another limitation is the quality of data registered in the “Under 2 Years Children Register”. Registrations could be improved at the clinic with a book that has even lines at both pages, better focus on the importance of data registration, and more staff at each session, for example, with an increased number of HSAs. In an immunisation session, previous vaccinations were not obtainable from the registration book. Actually, it had to be decided from the age of the child rather than the time since last immunisation was provided to estimate if the child had been immunised on correct time, and this may result in errors. It is important to know the time since the last dose was given to predict if children are being immunised timely, because then the vaccine is most beneficent.

Language barrier was a considerable limitation in the interviews. Even though the staff spoke English, Chichewa is the lingua franca in the area. This could cause misunderstanding in interviews and limited communication with those seeking healthcare services.

5.5 Outcome of immunisations

This study was not designed to measure outcome. Yet, the activities analysed here are evidenced interventions to reduce morbidity and mortality of children (111). The estimated number of incident cases of tuberculosis in Malawi was 181 per 100,000 in 2018, compared to 386 per 100,000 in 2000. Despite

this decline, tuberculosis is still a problem (112). Further, Malawi has been free from polio since 1991, although emphasis still needs to be on obtaining high vaccination coverage because all countries remain at risk until it has been eradicated (113). According to WHO, there were around 2,000 cases of diphtheria, 5,200 cases of tetanus and 1,400 cases of pertussis in Africa in 2018. This shows that although the vaccination coverage is high (76% for Africa), there are still cases of these diseases. (114). In 2015, the estimated prevalence of a hepatitis B surface antigen (which is a mark of a chronic or former infection) was 3% in U5 year old children in Malawi, compared to approximately 10% before the hepB vaccine was introduced (115). Diarrhoea caused roughly 2,300 deaths in children U5 years of age in Malawi in 2016, comparing to approximately 11,000 in 2000 (116). In 2019, 18 cases of measles were confirmed, which is similar to recent years (117). Taken together, these findings show that the incidence rate for many infections with high disease burden has been declining in recent years, thanks to ongoing immunisation efforts. Although high vaccination coverage rate has been obtained, emphasis needs to continue to deliver preventive services to avert a setback and reach even better outcomes, as new children are being born every day, and need immunisation to protect their health and wellbeing.

Despite controversy on the importance of growth monitoring in a setting such as the one in Mangochi District, coupled with Vitamin A supplementation, these interventions have potential that could be explored. Further research is needed to show how many children are underweight or stunted and why vitamin A is given to postpartum women instead of when they are pregnant and how it affects the outcome.

5.6 Conclusion

Preventive services, such as immunisation, growth monitoring and vitamin A administration are vital components in reducing U5M globally, thus reaching SDG target 3.2 and universal health coverage. Since Malawi reached MDG4 in 2013, with 71 deaths per 1,000 live births, the U5MR has continued to decline (4). In 2017 it was 55.4 deaths per 1,000 live births, representing an annual rate of decline of 6% since 2013 (118). Assuming that the U5MR continues to decrease with the same annual decline rate, Malawi will reach SDG Target 3.2 to reduce the U5MR to 25 per 1,000 live births by 2030. Thus, the evidence-based services analysed in this study may have contributed to this positive outcome and need to be strengthened further to improve the health and wellbeing of children in the district.

The pandemic, COVID-19, is now risking to reverse progress on achieving SDG3 (good health and well-being) (119). Along with SDG3, it also affects many of the other goals such as SDG1 (impoverishment), SDG2 (malnutrition) and SDG6 (clean water and sanitation) (119). Studies from other pandemics have shown that they can have a negative impact on immunisation coverage and utilisation of health facilities (120, 121). Time will have to reveal what affect it will have on the country and their ability to reach the SDGs.

This study is a contribution to the achievements of the SDGs. It is a part of the Countdown 2030 efforts by analysing how preventive services are conducted in a low-income setting, what can be improved and how Mangochi District is doing on reaching the SDG goals. It shows that utilisation of

health services is good both in Mangochi District and at MDH. The vaccination coverage was higher for immunisations provided earlier after birth compared to those provided later, yet still not all children are reached. The facility at the static clinic has improved since the inauguration of the new maternal wing while the working conditions could still be improved with more space and staff. Further, data registration needs to be improved for all preventive child health services offered in the district.

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Appendix 1. Selected socio-economic and health indicators for Malawi

Selected socio-economic and health indicators for Malawi *Taken from Human Development Report 2019 and UN data**	
General information	
Population (millions)	18
- *Under age 5*	2.8
- *Ages 15–64*	9.7
- *Ages 65 and older*	0.5
Population density (per km^2)	197.6
Fertility rate (total live births per woman)	4.9
Growth rate (average annual %)	2.8
Sex ratio at birth (male to female births)	97.3
Urban population (%)	17.2
Population using improved drinking-water sources (%)	69
Population using improved sanitation facilities (%)	26
Surface area (km^2)	118,484
Mortality rate (per 1,000 live births)	
- *infants*	52.6
- *under-five*	55.4
Infants lacking immunisation (% of one year olds)	
- *DPT*	4
- *measles*	13
Malaria incidence (per 1,000 people at risk)	231.1
Tuberculosis incidence (per 100,000 people)	131
Adolescent birth rate (births per 1,000 women ages 15-19)	132.7
Antenatal care coverage, at least one visit (%)	94.8
Maternal mortality ratio (deaths per 100,000 live births)	634
Proportion of births attended by skilled health personnel (%)	89.8
Education	
Expected years of schooling (years) (2014)	11
Literacy rate, adult (% ages 15 and older)	62.1

Income	
Gross domestic product (GDP)	
- *per capita (2019)*	340
- *total (2019 current US$)*	6,339
Poverty	
Population living below income poverty line,PPP $1.90 a day (%)	70.3
Population living below income poverty line, national poverty line (%)	51.5
Population vulnerable to multidimensional poverty (%)	28.5
Human Development Index	
Index	0.5
Rank	172

* Data refer to the most recent year available during the period specified.

Appendix 2. Questionnaire for interviews

Questionnaire for interviews with Health Surveillance Assistant

U5 clinic Mangochi District Hospital

Interview no. Age: Gender:

1. For how long have you worked at the Under-5 clinic?
2. Have you worked at another Under-5 clinic?
3. Do you like your work at MDH? Why?
4. What are the main challenges you are facing in your work at the Under-5 clinic?
5. How is your work schedule and how many are working at the Under-5 clinic each day?
6. What is your opinion on your working conditions? Have they changed since the inauguration of the new maternal wing at MDH?
7. What is the most significant change after the inauguration of the new maternal wing? (If you have worked at MDH since before the new unit opened)? What is lacking, if anything?
8. What guidelines and protocols do you use during work at the Under-5 clinic?
9. Have you had training for using those protocols? If yes, where and how was it?
10. Do you find the guidelines and protocols useful? Why? What is most useful for you and when?
11. What do you think is negative about the Under-5 clinic facilities and working conditions, if anything? Please specify and explain.
12. When do you get vaccine supplies to the clinic? Does it happen that you are out of stock with a vaccine? What do you do then?
13. Why do you think some guardians do not vaccinate their children?
14. Why do you think fewer children are brought in for their second and third doses of vaccines than the first dose at the Under-5 clinic?
15. Do you think growth monitoring is important? Please explain why.
16. Why do you think guardians bring their children to be weighted?
17. Do you get your salary paid at the right time? If yes, do you think it affects the services provided at the Under-5 clinic?
18. Is there something else you would like to add?

Appendix 3. Coverage calculations

Equations	
Coverage (for Mangochi District)	
- *for BCG and OPV0*	$\frac{\text{doses of vaccine}}{\text{live births}} * 100$
- *for other vaccinations*	$\frac{\text{doses of vaccine}}{\text{surviving infants}} * 100$
Drop-out[a]	$\frac{\text{doses of penta1 - doses of penta3}}{\text{doses of penta1}} * 100$
Underimmunised[a]	doses of penta1 – doses of penta3
Unimmunised[a]	$\frac{\text{surviving infants - doses of penta3}}{\text{surviving infants}} * 100$
FVC	children that have received all vaccination doses recommended
Coverage (for Mangochi District Hospital)	$\frac{\text{doses of vaccine}}{\text{children under 1 years old}} * 100$

[a] Are attributable to other vaccines
BCG: Bacillus Calmette-Guérin, OPV: Oral Poliovirus vaccine, IPV: Inactivated Poliovirus vaccine, Penta: Pentavalent vaccine, FVC: Fully vaccinated children