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# Is development aid to strengthen health systems during protracted conflict a useful investment? The case of South Sudan, 2011–2015

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## ABSTRACT

**Introduction** Is achievement of Sustainable Development Goal (SDG) 16 (building peaceful societies) a precondition for achieving SDG 3 (health and well-being in all societies, including conflict-affected countries)? Do health system investments in conflict-affected countries waste resources or benefit the public's health? To answer these questions, we examine the maternal, newborn, child and reproductive health (MNCRH) service provision during protracted conflicts and economic shocks in the Republic of South Sudan between 2011 (at independence) and 2015.

**Methods** We conducted two national cross-sectional probability surveys in 10 states (2011) and nine states (2015). Trained state-level health workers collected data from households randomly selected using probability proportional to size sampling of villages in each county. County data were weighted by their population sizes to measure state and national MNCRH services coverage. A two-sample, two-sided Z-test of proportions tested for changes in national health service coverage between 2011 (n=11 800) and 2015 (n=10 792).

**Results** Twenty-two of 27 national indicator estimates (81.5%) of MNCRH service coverage improved significantly. Examples: malaria prophylaxis in pregnancy increased by 8.6% (p<0.001) to 33.1% (397/1199 mothers, 95% CI ±2.9%), institutional deliveries by 10.5% (p<0.001) to 20% (230/1199 mothers, ±2.6%) and measles vaccination coverage in children aged 12–23 months by 11.2% (p<0.001) to 49.7% (529/1064 children, ±2.3%). The largest increase (17.7%, p<0.001) occurred for mothers treating diarrhoea in children aged 0–59 months with oral rehydration salts to 51.4% (635/1235 children, ±2.9%). Antenatal and postnatal care, and contraceptive prevalence did not change significantly. Child vitamin A supplementation decreased. Despite significant increases, coverage remained low (median of all indicators = 31.3%, SD = 19.7) . Coverage varied considerably by state (mean SD for all indicators and states=11.1%).

**Conclusion** Health system strengthening is not a uniform process and not necessarily deterred by conflict. Despite the conflict, health system investments were not wasted; health service coverage increased.

## Key questions

### What is already known?

- About 1.5 billion people currently living in fragile and conflict-affected settings have a heightened need for basic health services.
- Data on maternal, newborn, child and reproductive health service use by their populations are often scarce, reducing the ability of governments and health partners to track if health needs are being met and to effectively develop policies to strengthen the health system.
- Scarce information entrenches a common notion that 'war is development in reverse', which assumes that health systems cannot be strengthened during protracted conflict.

### What are the new findings?

- Our study, focusing on South Sudan, having had a protracted conflict for 20 years, demonstrated that in 5 years from the year of independence (2011) it made moderate progress in health system strengthening.
- However, progress varied across the states comprising the country, and coverage of maternal, newborn, child and reproductive health services is still low.

### What do the new findings imply?

- Health system strengthening is a context-specific non-uniform process and is not necessarily deterred by conflict.
- Aid to highly fragile countries from international agencies can result in important benefits for the intended populations, rather than being a waste of resources.

## INTRODUCTION

The increased global health focus on fragile and conflict-affected settings (FCAS) requires reliable evidence on the progress of health service delivery in FCAS. About 1.5 billion people currently living in FCAS have a heightened need for basic health services.[1] However, data on maternal, newborn, child

and reproductive health (MNCRH) service use by their populations are often scarce.[2] The limited information reduces the ability of governments and health partners to track if MNCRH needs are being met and to effectively develop policies to strengthen the health system.[3] This information scarcity also entrenches a common notion that 'war is development in reverse',[4] which assumes that health systems cannot be strengthened during protracted conflict, and can deter government and donor investments in these settings. However, despite their turmoil, FCAS like the Republic of South Sudan (RSS) have national policies guiding them along the world's ambitious path to achieve the Sustainable Development Goals (SDG), in which MNCRH and HIV/AIDS are key areas.[3 5 6] Hence, their need for information is acute, despite having challenging conditions. However, SDG 16 targets the building of peaceful societies as essential for sustainable development. Is achieving that goal a precondition in FCAS for achieving SDG 3 which promotes health and well-being in all societies?

In 2011, the RSS became the world's newest nation. Decades of civil war had destroyed much of the country's social fabric and physical infrastructure. Child and maternal mortality rates were among the highest in the world, and the highly fragmented health system was managed mostly by non-governmental organisations (NGO) and humanitarian aid organisations. Despite these extremely challenging starting conditions, RSS and international donors were eager to progress towards the millennium development goals.[7 8] In 2012, RSS became a Countdown to 2015 (CD2015) country for maternal, newborn and child survival,[3] and a pilot country of the New Deal for Engagement in Fragile States, a partnership among donor countries, FCAS and civil society to create country-led transitions out of fragility.[9 10]

However, between 2011 and 2015, RSS experienced unexpected economic and conflict-related shocks which may have slowed their health system development. In 2013, RSS leadership refused to sign the New Deal Compact with donors to establish benchmarks for peace and state building.[9 11] The collapse of global oil prices in 2014/2015 and renewed conflict with Sudan led to a year-long reduction in RSS's oil production, which contributed to a national economic crisis.[12 13] Domestic conflict erupted in December 2013 when President Salva Kiir accused his ex-vice-president, Riek Machar, of plotting a coup d'état. This conflict persists into 2019, leaving tens of thousands of people dead and hundreds of thousands displaced, and living with destroyed or limited infrastructure. This event strained relations between the government of RSS and the international community. In oil-producing states, 55% of health facilities no longer functioned in 2016.[14] RSS in 2019 is still a WHO grade 3 emergency country[15] and ranked first among 178 countries on the Fragile States Index,[16] making it a suitable location to address the question: can a health system strengthen during protracted conflicts?

Due to RSS's insecurity, current data on its progress towards health-related SDG indicators are scarce. In the final CD2015 report, RSS had the lowest score among 54 countries on the maternal, neonatal and child health composite coverage index.[3] However, these results are mostly based on pre-independence data, because the most recent Multiple Indicator Cluster Survey (MICS) was conducted in 2010.[17] Similarly, a recent literature review of their MNCRH progress reported key indicators only for the period from 2000 to 2010.[18] Other recent publications with relevant quantitative results[19–21] also assessed the MICS 2010 data, with a few exceptions.[22 23]

Despite the challenging circumstances and widespread civil conflict, the Ministry of Health (MOH) conducted two national household probability surveys: 2011 (the year of independence) and 2015 (the SDG baseline year) providing the most comprehensive national, state and county-level health estimates available. Here, we examine the progress in MNCRH coverage indicators in RSS in the context of a protracted political-military conflict and economy-related shocks. Our findings provide unique insight into how a fragile health system performs during such conditions and whether or not investment in an FCAS benefits the public's health rather than wastes resources.

## METHODS

### Overall study design

The two national cross-sectional household surveys were stratified random samples of each state in which substrata were counties. County-level data were produced with lot quality assurance sampling (LQAS) and analysed at a state level as a stratified random sample. Being relatively inexpensive and rapid to carry out at a local level, this established method was well suited to South Sudan for managing state-health services.[24] A detailed description of the sampling design and procedures was reported earlier[23]; the 2015 survey protocol replicated the 2011 design. The national and state MOHs selected this method as it permitted classification of each county by national performance benchmarks, and also computation of national and state-level indicator prevalence estimates with 95% CIs. We used the classic LQAS method[25] and training materials[26 27] to build the capacity of state and county health workers to collect the data.

### Sampling and participants

For both surveys we planned to include all 10 South Sudan states and all counties within the states, unless they were highly insecure or inaccessible due to environmental barriers. Despite ongoing armed conflict, we surveyed all states in 2011, but excluded Unity State in 2015 which was under rebel control and highly insecure. Armed conflict and political negotiations slightly changed state and county boundaries, so the total number of counties within the states differed between 2011 (79 counties) and 2015 (85 counties). We also subdivided two large

counties in Western Bahr el Ghazal in 2011 and 2015 to better reflect health system management. Also, in 2015, we aggregated seven small counties to form four bigger counties in the newly designated, semiautonomous Greater Pibor Administrative Area (GPAA). We excluded six counties in 2011 and four counties (plus the nine counties of the excluded Unity State) in 2015 due to insecurity or inaccessibility. In total, this study included 75 of 81 counties/subdivisions in 2011 and 71 of 84 counties/subdivisions in 2015 (online supplementary table S1).

We selected villages and households using a standard two-stage sampling procedure. First, we selected 19 interview locations (usually 19 villages) within each county/subdivision of each state using probability proportional to size sampling[23] (2011: n=75 counties×19 villages=1425; 2015: n=71 counties×19 villages=1349, online supplementary table S1). We then used segmentation sampling to randomly select households within these villages using a hand-drawn map.[28 29]

Within households, we used a 'parallel sampling' process[26 30] to sample eight different client populations, to ensure a sufficient sample size for assessing each one. Six client populations were mothers of children: (1) <12 months, (2) 12–23 months, (3) 0–59 months, (4) 0–59 months with fever in the last 2 weeks, (5) 0–59 months with diarrhoea in the last 2 weeks, and (6) 0–59 months with suspected pneumonia in the last 2 weeks; two others were women and men aged 15–49 years. As each population had its own independent sample, the total sample collected in 2011 was 11 800 (1475×8 client populations), and 10 792 (1349×8 client populations) in 2015.

On arrival at the first randomly selected household, the next closest house was selected to reduce the chance of any house not appearing on the segmentation map having a zero probability for selection. The interviewer listed all household members who met the criteria for any of the eight client populations and selected one person randomly for interview. After the interview, the interviewer moved to the next nearest household; the same process continued until one person of each client population was interviewed in each sample location (see ref 23 for more details). Client populations 4–6 could also be selected in the same house as other client populations due to their low prevalence.

Data collection was supervised by national and state supervisors and some of the authors who were in daily mobile telephone communication with the data collectors whom they had trained. Questionnaires were reviewed daily for missing information by supervisors, and corrected by the corresponding data collector when needed. Data were collected in the dry season using vehicles and boats when needed.

### Study instruments and indicators

Jointly with multiple national stakeholders, we developed separate structured questionnaires for each client population, based on internationally recognised and standardised indicators[31–34] (table 1). For use in the northern states, questionnaires were translated from English into Arabic and back-translated for verification. In other locations, key terms in the questionnaires were translated into major local languages and back-translated into English to ensure consistency with the language used. Questionnaires were refined for the local context during pretesting.

### Data collection and analysis

Immediately before data collection, we held training workshops at subregional venues throughout South Sudan for 237 persons in 2011 and 162 persons in 2015, most of whom were county health department staff selected by their respective state MOH. In 2015, as selected health department staff in counties in Upper Nile (UN) and Jonglei, under rebel control, could not travel to training venues due to insecurity, we trained staff of partner NGOs as replacements. All data were collected in the non-rainy season (2011: April and May; 2015: February and March). In 2015, data collection was delayed due to insecurity in UN, Jonglei and GPAA until April to June.

Questionnaire data were entered in CSPro V.4.0.004 in Juba using double data entry for a portion of the data in 2011 and for all data in 2015. We analysed data using Excel V.2013, Stata V.14 and R V.3.2.3. For each indicator, we computed national and state-level coverage proportions and 95% CIs, weighted by county population sizes. We used 'Curtailed Sampling'[35] to adjust for missing data in the 2011 data set, as explained previously.[23] In 2015, missing data were negligible (table 2). As we did not survey Unity State in 2015, we excluded it from the 2011 data set for this comparative national-level analysis. We used a two-sample, two-sided Z-test of proportions to test for change between 2011 and 2015.

### Patient and public involvement

This study does not involve patients. Also, the public were not involved in the design, conduct and reporting of the research. The public were engaged as interviewees. To ensure local engagement all data capture was carried out jointly with the national and state MOHs of the RSS. We also shared the results with them and offered further dissemination of results, and engaged them for data use and action planning activities.

## RESULTS

### Participants and response rate

Data collectors identified eligible respondents in 93.1% of visited households in 2011 (response rate: 96.2%), and 93.3% in 2015 (response rate: 96.4%). Among the eight client population groups in all nine states included in this study, we completed a total of 9710 interviews in 2011 and 10 784 interviews in 2015 (table 2).

The mean age of participants was similar for the eight client populations in both surveys (range: 27–33 years) (table 2). Most mothers (86%–91%) and women and men aged 15–49 years (65%–77%) were married; the educational status for men and women, defined as

**Table 1** Indicators used during the household surveys in South Sudan, 2011 and 2015

| Indicator | | Definition | Client population* (for denominators) | Indicator source† |
|---|---|---|---|---|
| *Maternal and neonatal care* | | | | |
| 1 | ANC 4+ | % women who received antenatal care by any health personnel ≥4 times during last pregnancy | MoC <12 months | MDG 5.5, CD2015 |
| 2 | Malaria prophylaxis | % women who received ≥2 IPTs for malaria during pregnancy | MoC <12 months | CD2015 |
| 3 | Tetanus prophylaxis | % mothers who received ≥2 tetanus toxoid injections before the birth of their youngest child or had lifetime immunity (card confirmed) | MoC <12 months | Related to CD2015 |
| 4 | Institutional delivery¶ | % women who delivered in a health facility during last pregnancy | MoC <12 months | UHC |
| 5 | PNC for mother | % women with ≥1 postnatal care visit within 6 weeks post partum with any health personnel during last pregnancy | MoC <12 months | Related to CD2015 |
| *Child immunisation* | | | | |
| 6 | Measles vaccination | % children who received ≥1 dose of measles vaccine | MoC 12–23 months | MDG 4.3, CD2015, UHC |
| 7 | DPT3 vaccination | % children who received three DPT vaccinations | MoC 12–23 months | CD2015, UHC |
| 8 | All basic vaccines | % children who received all basic vaccines (1 BCG, 4 OPV, 3 DPT, 1 measles) | MoC 12–23 months | UHC |
| *Childcare* | | | | |
| 9 | Vitamin A supplementation | % children aged 6 months to 5 years who received vitamin A supplementation in the past 6 months | MoC 0–59 months | Related to CD2015 |
| 10 | Malaria treatment | % children with fever who received appropriate antimalarial drugs (ACT) | MoC 0–59 months with fever in the past 2 weeks | MDG 6.8, CD2015, UHC |
| 11 | Diarrhoea treatment | % children treated with ORS | MoC 0–59 months with diarrhoea in the past 2 weeks | CD2015 |
| 12 | Pneumonia care seeking | % children with suspected pneumonia taken to an appropriate health provider | MoC 0–59 months with fast, difficult breathing in the past 2 weeks | CD2015, UHC |
| *HIV testing* | | | | |
| 13a/13b | HIV testing, women/men | % women/men tested for HIV in the last 12 months and received their results | Women/men 15–49 years | GARPR |
| *HIV-related knowledge* | | | | |
| 14a/14b | MTCT knowledge, women/men | % women/men who know 2+ ways in which HIV is transmitted from an infected mother to her child | Women/men 15–49 years | |
| 15a/15b | Prevention knowledge‡, women/men | % women/men who correctly identify using condoms and being faithful as ways of preventing sexual HIV transmission | Women/men 15–49 years | HIV SID 4.1 |
| 16a/16b | Misconception knowledge 1‡ (mosquito), women/men | % women/men who correctly reject the misconception that HIV can be transmitted by mosquito bites | Women/men 15–49 years | HIV SID 4.2.2 |

Continued

**Table 1** Continued

| Indicator | | Definition | Client population* (for denominators) | Indicator source† |
|---|---|---|---|---|
| 17a/17b | Misconception knowledge 2‡ (food), women/men | % women/men who correctly reject the misconception that HIV can be transmitted by sharing food with an infected person | Women/men 15–49 years | HIV SID 4.2.6 |
| 18a/18b | Misconception knowledge 3‡ (witchcraft), women/men | % women/men who correctly reject the misconception that HIV can be transmitted by witchcraft | Women/men 15–49 years | HIV SID 4.2.3 |
| *STI-related knowledge* | | | | |
| 19a | STI knowledge, women | % women who know at least two signs/symptoms of STIs in women | Women 15–49 years | Related to BSS |
| 19b | STI knowledge, men | % men who know at least two signs/symptoms of STIs in men | Men 15–49 years | Related to BSS |
| *Contraception and HIV prevention* | | | | |
| 20 | Contraception among non-pregnant women (modern)§ | % women of reproductive age, currently not pregnant†, using at least one modern contraception method | Women 15–49 years | Related to UHC |
| 21 | Contraception among all married women (modern)§ | % married women of reproductive age, using at least one modern contraception method | Women 15–49 years | UHC |
| 22a/22b | Condom use women/men | % women/men who reported use of a condom the last time they had sex with a non-marital or non-cohabiting partner in the past 12 months | Women/men 15–49 years | Related to MDG 6.2 |

*MoC <12 months=mothers of children aged less than 12 months; MoC 12–23 months=mothers of children aged 12–23 months; MoC 0–59 months=mothers of children aged 0–59 months.
†For 2015, we computed this indicator with all women (pregnant and non-pregnant) in the denominator, per the UHC indicators and also MDG indicators, although the latter do not restrict contraception to modern methods, but include traditional methods.
‡We did not combine prevention and misconception knowledge indicators because national stakeholders predicted knowledge to be very low, which would have resulted in extremely low estimates for composite indicators.
§Modern methods of contraception include female and male sterilisation, oral hormonal pills, intrauterine devices, male and female condoms, injectables, implants (including Norplant), vaginal barrier methods and spermicides.
¶Institutional delivery means delivery in a hospital, or primary healthcare clinic (PHCC).
ACT, artemisinin-based combination therapy; ANC, antenatal care; BSS, Behavioral Surveillance Survey; CD2015, Countdown to 2015 for maternal, newborn and child survival; DPT, diphtheria/pertussis/tetanus; GARPR, Global AIDS Response Progress Reporting indicators (before 2012 known as UNGASS indicators); HIV SID, HIV/AIDS Survey Indicator Database; IPT, intermittent preventive treatment; MDG, Millennium Development Goal; MTCT, mother-to-child transmission of HIV; OPV, Oral Polio Vaccine; ORS, oral rehydration salts; PNC, postnatal care; STI, sexually transmitted infection; UHC, universal health coverage; UNGASS, United Nations General Assembly Special Session.

having received any formal schooling, was very low especially among women (2011: 18%–27%, 2015: 26%–32%). Literacy, assessed in 2015 only, was very low with only 11.7% of women aged 15–49 years and 33.0% of men aged 15–49 years able to read a short sentence. Literacy varied substantially by state (range: 3.4% in Northern Bahr el Ghazal (NBeG) to 27.1% in Central Equatoria for women aged 15–49 years, online supplementary table S2).

### National-level MNCRH indicators

Between 2011 and 2015, of the 27 national healthcare indicators measured, 22 improved (81.5%), 4 remained similar and 1 indicator declined (table 3). For national estimates for antenatal care (ANC) and postnatal care (PNC) indicators remained unchanged at low levels in 2015, with less than one-quarter of women attending ≥4 ANC (ANC4+, 22.4%, 95% CI ±2.5) or receiving ≥1 PNC visit (22.8%, 95% CI ±2.5). The proportion of mothers having institutional deliveries, however, increased by 10.5% (p<0.001), but overall remained low with only 27.0% (95% CI ±2.5) of mothers delivering at a health facility in 2015. Malaria prophylaxis in pregnancy increased by 8.6% (p<0.001) to 33.1% (95% CI ±2.9%).

Three of four childcare indicators showed significant improvement, with the highest increase being among children with malaria treated with a first-line antimalarial (15.8% increase, p<0.001) and diarrhoea treatment (17.7% increase, p<0.001) (table 3). Child immunisation coverage improved significantly by 2015 (p<0.001) but remained low with about half of the children obtaining

**Table 2** Study population characteristics (unweighted), South Sudan household survey, 2011 and 2015

| | 2011 survey* | | | | | 2015 survey | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Client population | Sample size, n† | Mean age, years (SD) | Married, n (%) | Received any formal schooling, n (%) | Respondent's child's mean age, months (SD) | Sample size, n‡ | Mean age (SD) | Married, n (%) | Received any formal schooling, n (%) | Respondent's child's mean age, months (SD) |
| Mothers of children aged <12 months | 1199 | 28.2 (6.6) | 1094 (91.7) | 287 (23.9) | 6.1 (3.3) | 1348 | 27.1 (6.7) | 1179 (87.5) | 414 (30.7) | 6.1 (3.1) |
| Mothers of children aged 12–23 months | 1064 | 28.5 (7.7) | 957 (89.9) | 234 (22.0) | 16.8 (3.8) | 1348 | 28.3 (6.9) | 1182 (87.7) | 377 (28.0) | 16.9 (3.7) |
| Mothers of children aged 0–59 months | 1237 | 29.9 (7.0) | 1123 (90.8) | 274 (21.9) | 27.0 (15.1) | 1348 | 29.1 (7.4) | 1160 (86.1) | 350 (26.0) | 29.0 (15.9) |
| Mothers of children age 0–59 months with fever in the past 2 weeks | 1249 | 29.3 (6.8) | 1118 (90.8) | 230 (18.4) | 25.6 (16.1) | 1348 | 28.8 (7.2) | 1153 (85.5) | 351 (26.0) | 23.6 (15.7) |
| Mothers of children aged 0–59 months with diarrhoea in the past 2 weeks | 1235 | 29.6 (6.9) | 1122 (90.6) | 261 (20.8) | 24.1 (15.4) | 1348 | 28.4 (7.3) | 1177 (87.3) | 363 (26.9) | 23.3 (15.7) |
| Mothers of children aged 0–59 months with fast, difficult breathing in the past 2 weeks | 1235 | 29.5 (7.4) | 1112 (90.4) | 260 (20.8) | 25.0 (16.0) | 1348 | 28.4 (6.8) | 1170 (86.8) | 370 (27.4) | 22.0 (14.7) |
| Women 15–49 years | 1246 | 28.3 (8.4) | 838 (67.5) | 330 (26.5) | NA | 1348 | 28.4 (8.1) | 1038 (77.0) | 433 (32.1) | NA |
| Men 15–49 years | 1245 | 32.1 (8.8) | 799 (64.8) | 607 (48.8) | NA | 1348 | 32.9 (9.0) | 1041 (77.2) | 695 (51.6) | NA |

*The 2011 survey included Unity State, which we exclude here to compare the 2011 and 2015 results.
†The 2011 sample size should have been 66 counties×19 villages=1254 for all eight client populations (see online supplementary table S1), but was reduced for all of the client populations due to missing data.
‡The 2015 sample size should have been 71 counties×19 villages=1349 interviews per client population, but was actually 1348, as the records of one village were missing.
NA, not applicable; SD, Standard Deviation.

**Table 3** Progress in health service coverage (2011–2015) and national coverage proportions in 2015

| Indicator | 2015 vs 2011 difference in weighted coverage proportions (%) (95% CI (%))* | P value* | Weighted national coverage proportions (%), 2015 (95% CI (%)) | HSDP† coverage target (%) for 2015 |
|---|---|---|---|---|
| **Maternal and neonatal care** | | | | |
| ANC 4+ | 1.6 (±3.4) | 0.358 | 22.4 (±2.5) | 40 |
| Malaria prophylaxis | 8.6 (±3.9) | <0.001 | 33.1 (±2.9) | 40 |
| Tetanus prophylaxis | 3.1 (±3.1) | 0.047 | 13.7 (±2.3) | 80 |
| Institutional delivery | 10.5 (±3.4) | <0.001 | 27.0 (±2.6) | 25 |
| PNC for mother (any provider) | 1.7 (±3.6) | 0.359 | 22.8 (±2.6) | |
| **Child immunisation** | | | | |
| Measles vaccination | 11.2 (±4.2) | <0.001 | 49.7 (±2.8) | |
| DPT3 vaccination | 13.1 (±3.6) | <0.001 | 34.7 (±2.6) | 85 |
| All basic vaccines | 11.3 (±3.0) | <0.001 | 20.8 (±2.3) | 50† |
| **Childcare** | | | | |
| Vitamin A supplementation | –26.4 (±3.2) | <0.001 | 4.8 (±1.6) | 80 |
| Malaria treatment (ACT) | 15.8 (±3.6) | <0.001 | 31.3 (±2.8) | |
| Diarrhoea treatment (ORS) | 17.7 (±4.1) | <0.001 | 51.4 (±2.9) | 80 |
| Pneumonia care seeking | 5.9 (±4.0) | 0.004 | 66.1 (±2.8) | |
| **HIV testing** | | | | |
| HIV testing, women | 7.3 (±2.8) | <0.001 | 17.0 (±2.2) | NA |
| HIV testing, men | 8.2 (±2.9) | <0.001 | 18.6 (±2.3) | NA |
| **HIV-related knowledge** | | | | |
| MTCT knowledge, women | 6.0 (±2.9) | <0.001 | 17.3 (±2.4) | NA |
| MTCT knowledge, men | 6.6 (±3.4) | <0.001 | 23.1 (±2.7) | NA |
| HIV prevention knowledge, women | 0.5 (±1.9) | 0.641 | 8.9 (±1.6) | NA |
| HIV prevention knowledge, men | 1.9 (±3.0) | 0.218 | 17.6 (±2.3) | NA |
| HIV misconception knowledge 1 (mosquito), women | 7.0 (±4.0) | 0.001 | 38.5 (±2.9) | NA |
| HIV misconception knowledge 1 (mosquito), men | 6.9 (±4.0) | 0.001 | 48.8 (±2.8) | NA |
| HIV misconception knowledge 2 (food), women | 8.8 (±3.6) | <0.001 | 55.1 (±2.6) | NA |
| HIV misconception knowledge 2 (food), men | 7.1 (±3.7) | <0.001 | 64.0 (±2.6) | NA |
| HIV misconception knowledge 3 (witchcraft), women | 12.1 (±3.9) | <0.001 | 60.2 (±2.6) | NA |
| HIV misconception knowledge 3 (witchcraft), men | 6.8 (±3.7) | <0.001 | 68.1 (±2.5) | NA |
| **STI-related knowledge** | | | | |
| STI knowledge, women | 9.4 (±3.8) | <0.001 | 48.6 (±2.8) | NA |
| STI knowledge, men | 12.0 (±4.0) | <0.001 | 58.1 (±2.9) | NA |
| **HIV prevention and contraception** | | | | |
| Contraception (non-pregnant) | 0.6 (±2.6) | 0.653 | 7.1 (±1.9) | NA |
| Contraception (all married) | nc | | 4.9 (±1.6) | 20 |
| Condom use, women | nc | | 18.0 (±9.1) | NA |
| Condom use, men | nc | | 38.2 (±6.7) | NA |

*Results of two-sample, two-sided Z-test of proportions to test for significant change between 2011 and 2015.
†The HSDP target refers to card-confirmed vaccinations, while our indicators include mothers' oral report of vaccinations.
ACT, artemisinin-based combination therapy; ANC, antenatal care; CI, Confidence Interval; DPT, diphtheria/pertussis/tetanus; HSDP, Health Sector Development Plan for the Republic of South Sudan; MTCT, mother-to-child transmission; NA, not applicable; nc, not computed comparative results, as explained above; ORS, oral rehydration salts; PNC, postnatal care; STI, sexually transmitted infection.

a measles vaccination (49.7%, 95% CI ±2.8), and about one-fifth receiving all basic vaccinations (20.8%, 95% CI ±2.3). Nevertheless, the proportion of children with first-line malaria and diarrhoea treatment remained low at 31.3% (95% CI ±2.8) and 51.4% (95% CI ±2.9), respectively. The only indicator displaying a decreased coverage was child vitamin A supplementation (26.4% decrease, p<0.001), which fell to a very low 4.8% (95% CI ±1.6) in 2015.

Estimates for most HIV/AIDS and sexually transmitted infection (STI) indicators improved only slightly, although significantly. HIV testing coverage among women aged 15–49 years increased by 7.3% (p<0.001) reaching 17.0% (95% CI ±2.2) coverage by 2015 (table 3). The only HIV-related indicator that did not increase was the proportion of women and men who knew how to prevent sexual HIV transmission through condom use and staying faithful to one partner; it remained low (8.9% and 17.6%). Similarly, the modern contraceptive prevalence rate among non-pregnant women aged 15–49 years remained unchanged at a low 7.1% (95% CI ±1.9). We were unable to compute differences in the condom use indicator during high-risk sexual contacts, because of a small number of people who responded positively in 2011 and 2015 to the question for the denominator (having had extramarital sex), and a relatively large number of missing values in 2011. Nevertheless, the 2015 national coverage estimates were very low.

Although 81.5% of the indicators improved, their values remained low with a median value of 31.3% (SD=19.7) (table 3).

### State-level MNCRH indicators

Coverage in the nine states varied considerably for the 27 indicators. On average the state coverages varied by 11.1% for each indicator (table 4).

Central Equatoria State (CES) displayed the highest coverage rates for almost all MNCRH indicators; the performance of the other states and their improvement rates varied considerably across the different indicators (table 4, online supplementary figures S1–S28). Four of the nine states significantly increased their rate for institutional delivery with the highest (26.0% increase, p<0.001) being CES. Overall, coverage with MNCRH services remained low for most states, ranging from 13.0% (95% CI ±5.7) in UN to 55.1% (95% CI ±9.4) in CES for institutional delivery, from 6.7% (95% CI ±4.1) in UN to 32.4% (95% CI ±10.0) in CES for mothers of infants having received at least two tetanus toxoid vaccinations during pregnancy, from 7.6% (95% CI ±4.4) in Warrap to 48.6% (95% CI ±9.4) in CES for completed basic vaccinations for children 12–23 months of age and 21.7% (95% CI ±5.8) in Jonglei/GPAA to 53.4% (95% CI ±10.2) in CES for treatment of children <5 years with malaria with an appropriate antimalarial. The highest coverage was found in CES for seeking healthcare for a child aged 0–59 months with suspected pneumonia (82.2%, 95% CI ±7.8).

table 4. For most states, coverage proportions for HIV and STI-related indicators either did not change significantly or increased, with one of the biggest increases (22.9%, p<0.001) noted for the HIV testing indicator among men in WES reaching 50.5% by 2015. WES performed best for most HIV and STI-related and contraception indicators, except for the indicators on HIV-related misconceptions. For example, the proportion of women who correctly rejected the misconception that HIV can be transmitted by witchcraft decreased by 31.1% (p<0.001) to 42.5% in WES. Conversely, in CES this indicator increased by 24.4% (p<0.001) to 86.0% (data on the state-level statistical tests not shown).

The modern contraception prevalence rate among non-pregnant women remained low level at ≤6% in seven states; however, in WES and CES it increased to 26.4% (95% CI ±8.4) and 16.7% (95% CI ±9.9), respectively (table 4).

## DISCUSSION

### National-level performance

Despite severe economic and political-military crises, RSS displayed increases in health service coverage for 22 of 27 indicators since its independence in 2011. The increase in vaccination, and malaria prophylaxis and treatment coverage has also been found in other low and middle-income countries.[3 36] The increased rate of females having an HIV test is consistent with the increase noted in facility data among pregnant women.[37] This is a welcomed result since RSS has a generalised HIV epidemic (adult HIV prevalence: 2.7%, 2014 estimate) and high levels of STIs.[38] Knowledge of one's HIV status is a prerequisite for accessing antiretroviral therapy (ART). While ART targets for 2015 have been met globally,[39] RSS has only recently begun scaling up ART. In 2013, RSS had the second highest death rate among people living with HIV in 30 countries.[40] Since 2013, the number of people living with HIV/AIDS on ART in RSS has increased by 260% from 7755 to 28 086.[41]

The increases we detected among the 22 indicators took place while both local and international efforts had been focusing on health system strengthening (HSS). Following independence, and in line with new international agreements, the MOH implemented a policy of unifying the highly fragmented health system under its control, which after decades of war and humanitarian assistance had been managed mainly by NGOs (≥76 NGOs and six United Nations agencies).[37] While NGOs still maintained an essential role in the health system, donors mainly focused on strengthening the entire health system, including the central level.

The HSS support to RSS included improving MOH's capacity in human resources for health (HRH), health financing, governance and information systems,[42] and strengthening service delivery and informatics. The World Bank's funding for the Umbrella Program for Health System Development (2009–2012) financed the

**Table 4** Weighted state proportions for MNCRH, HIV and STI indicators, South Sudan household survey, 2015

| | Weighted state coverage proportions (%) and in parenthesis 95% CI (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Indicator*** | **UN** | **Jonglei/GPAA** | **Warrap** | **NBeG** | **WBeG** | **Lakes** | **WES** | **CES** | **EES** |
| **Maternal and neonatal care** | | | | | | | | | |
| ANC 4+ | 21.4 (±7.2) | 11.0 (±3.6) | 9.9 (±5.1) | 27.6 (±10.7) | 37.7 (±9.3) | 18.6 (±6.6) | 30.7 (±7.7) | 40.0 (±9.7) | 19.4 (±6.2) |
| Malaria prophylaxis | 36.0 (±8.9) | 29.8 (±6.3) | 24.3 (±6.4) | 43.1 (±12.3) | 36.4 (±10.9) | 33.7 (±8.2) | 36.7 (±8.2) | 42.4 (±10.1) | 22.3 (±6.4) |
| Tetanus prophylaxis | 6.7 (±4.1) | 8.8 (±4.1) | 8.0 (±5.3) | 12.0 (±8.3) | 17.6 (±9.2) | 8.9 (±4.9) | 16.6 (±6.8) | 32.4 (±10.0) | 9.7 (±5.0) |
| Institutional delivery | 13.0 (±5.7) | 14.9 (±4.9) | 14.1 (±6.0) | 25.3 (±11.0) | 42.6 (±10.9) | 26.5 (±7.5) | 37.6 (±8.0) | 55.1 (±9.4) | 21.7 (±6.2) |
| PNC for mother | 20.0 (±7.2) | 11.8 (±4.3) | 25.1 (±7.7) | 36.2 (±11.7) | 6.2 (±2.9) | 10.8 (±5.5) | 37.8 (±7.5) | 27.9 (±8.7) | 26.9 (±6.9) |
| **Child immunisation** | | | | | | | | | |
| Measles vaccination | 46.7 (±9.0) | 56.5 (±6.4) | 27.7 (±8.3) | 26.6 (±9.3) | 48.5 (±8.8) | 49.4 (±8.5) | 55.4 (±7.7) | 73.1 (±8.7) | 51.7 (±7.8) |
| DPT3 vaccination | 25.5 (±8.0) | 23.1 (±5.8) | 21.0 (±7.4) | 19.3 (±8.1) | 51.1 (±10.0) | 23.1 (±6.9) | 42.8 (±8.0) | 70.1 (±8.3) | 39.0 (±6.8) |
| All basic vaccines | 18.8 (±7.4) | 9.6 (±4.3) | 7.6 (±4.4) | 11.3 (±5.9) | 41.1 (±9.0) | 16.4 (±6.3) | 19.0 (±7.0) | 48.6 (±9.4) | 23.9 (±6.4) |
| **Childcare** | | | | | | | | | |
| Vitamin A supplementation | 5.0 (±4.6) | 4.6 (±4.1) | 0.9 (±1.1) | 2.7 (±2.6) | 9.7 (±10.1) | 3.2 (±3.2) | 12.9 (±8.0) | 3.5 (±5.1) | 8.4 (±6.6) |
| Malaria treatment | 30.9 (±8.5) | 21.7 (±5.8) | 24.8 (±6.9) | 38.4 (±11.7) | 24.1 (±8.9) | 25.8 (±7.4) | 27.2 (±7.0) | 53.4 (±10.2) | 29.1 (±7.2) |
| Diarrhoea treatment | 50.9 (±8.2) | 55.6 (±6.2) | 38.9 (±8.1) | 64.6 (±10.7) | 36.3 (±10.1) | 49.7 (±8.1) | 56.6 (±7.4) | 60.5 (±10.3) | 40.8 (±7.7) |
| Pneumonia care seeking | 57.2 (±8.1) | 64.9 (±6.1) | 54.4 (±8.7) | 59.7 (±12.4) | 52.0 (±10.8) | 72.6 (±7.1) | 81.6 (±6.1) | 82.2 (±7.8) | 61.1 (±7.7) |
| **HIV testing** | | | | | | | | | |
| HIV testing, women | 4.9 (±3.5) | 10.4 (±4.3) | 2.8 (±2.9) | 3.7 (±5.6) | 33.2 (±7.8) | 6.9 (±4.3) | 52.2 (±7.6) | 29.1 (±9.3) | 21.7 (±6.6) |
| HIV testing, men | 9.6 (±5.5) | 11.6 (±4.5) | 4.6 (±3.8) | 8.1 (±5.5) | 18.6 (±8.6) | 12.2 (±5.7) | 50.5 (±7.8) | 34.3 (±9.8) | 20.0 (±6.4) |
| **HIV-related knowledge** | | | | | | | | | |
| MTCT knowledge, women | 20.4 (±7.2) | 15.0 (±5.0) | 16.4 (±6.9) | 20.0 (±9.8) | 6.3 (±6.5) | 18.1 (±6.5) | 29.7 (±7.0) | 17.9 (±7.6) | 11.5 (±5.2) |
| MTCT knowledge, men | 31.4 (±7.2) | 21.6 (±5.7) | 24.1 (±8.2) | 19.9 (±10.4) | 18.4 (±10.0) | 23.1 (±7.2) | 30.2 (±7.1) | 21.5 (±8.5) | 20.8 (±6.4) |
| Prevention knowledge, women | 13.6 (±6.8) | 10.5 (±4.5) | 0.3 (±0.6) | 4.5 (±6.1) | 3.8 (±4.0) | 2.1 (±2.5) | 29.8 (±6.9) | 11.3 (±4.3) | 6.6 (±4.1) |
| Prevention knowledge, men | 23.0 (±7.6) | 18.1 (±5.4) | 7.9 (±5.6) | 12.1 (±8.8) | 11.1 (±7.5) | 18.0 (±6.9) | 39.2 (±7.4) | 23.2 (±7.2) | 8.6 (±4.2) |
| Misconception knowledge 1 (mosquito), women | 44.3 (±8.4) | 31.7 (±6.4) | 25.8 (±8.3) | 47.7 (±11.9) | 35.4 (±7.4) | 21.3 (±7.2) | 39.3 (±7.9) | 60.1 (±9.7) | 39.0 (±7.4) |
| Misconception knowledge 1 (mosquito), men | 60.0 (±7.5) | 41.0 (±6.7) | 37.8 (±9.3) | 40.8 (±12.0) | 43.7 (±7.2) | 34.0 (±8.4) | 43.4 (±8.3) | 82.2 (±6.1) | 48.2 (±7.4) |
| Misconception knowledge 2 (food), women | 45.0 (±8.5) | 40.7 (±6.4) | 25.1 (±8.0) | 55.6 (±11.4) | 70.7 (±9.0) | 49.1 (±8.6) | 74.9 (±6.8) | 84.4 (±5.6) | 64.1 (±6.4) |
| Misconception knowledge 2 (food), men | 58.1 (±8.3) | 51.5 (±6.7) | 51.2 (±8.6) | 58.1 (±11.8) | 65.4 (±9.5) | 57.2 (±8.4) | 81.5 (±5.9) | 91.3 (±4.7) | 63.8 (±6.5) |
| Misconception knowledge 3 (witchcraft), women | 47.0 (±8.7) | 51.3 (±6.1) | 50.4 (±8.8) | 73.1 (±9.5) | 73.2 (±10.0) | 54.9 (±8.7) | 42.5 (±5.8) | 86.0 (±6.6) | 62.0 (±6.6) |

Continued

**Table 4** Continued

| Indicator* | Weighted state coverage proportions (%) and in parenthesis 95% CI (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | UN | Jonglei/GPAA | Warrap | NBeG | WBeG | Lakes | WES | CES | EES |
| Misconception knowledge 3 (witchcraft), men | 63.0 (±7.4) | 56.2 (±6.2) | 67.9 (±8.6) | 84.9 (±7.9) | 81.3 (±9.3) | 62.8 (±8.2) | 49.6 (±6.1) | 87.6 (±6.5) | 64.1 (±6.6) |
| **STI-related knowledge** | | | | | | | | | |
| STI knowledge, women | 31.7 (±8.0) | 45.4 (±5.4) | 45.7 (±7.7) | 49.4 (±10.9) | 38.4 (±11.2) | 45.2 (±8.2) | 58.8 (±7.5) | 68.9 (±9.5) | 40.7 (±6.8) |
| STI knowledge, men | 37.8 (±8.3) | 60.4 (±6.5) | 63.3 (±7.5) | 62.9 (±9.4) | 46.8 (±11.9) | 53.3 (±7.7) | 69.2 (±7.5) | 65.9 (±9.9) | 48.5 (±8.0) |
| **HIV prevention and contraception** | | | | | | | | | |
| Contraception among non-pregnant women | 4.3 (±3.5) | 0.4 (±0.6) | 1.8 (±2.8) | 5.5 (±6.0) | 3.0 (±5.0) | 3.3 (±3.9) | 26.4 (±8.4) | 16.7 (±9.9) | 6.0 (±4.5) |
| Contraception among all married women | 2.5 (±2.5) | 0.4 (±0.5) | 1.6 (±2.4) | 5.0 (±5.5) | 2.3 (±4.5) | 2.7 (±3.1) | 16.3 (±7.1) | 12.4 (±7.9) | 4.4 (±3.8) |

We do not report state-level results for the condom use indicators, because sample sizes for this indicator were too small due to a combination of the low number of persons responding affirmatively to the related questions for the construction of the denominator (having engaged in extramarital sex) and numerator (having used a condom at last extramarital sex) and missing values.

*For indicator definitions see table 1.

ACT, Artemisinin-based combination therapy; ANC, antenatal care; CES, Central Equatoria; DPT, diphtheria/pertussis/ tetanus; EES, Eastern Equatoria; GPAA, Greater Pibor Administrative Area; int. ind, international indicator (including both married and unmarried women, excluding pregnant women); Jong, Jonglei; know, knowledge; m, men; MTCT, Mother to Child Transmission; NBeG, Northern Bahr el Ghazal; ORS, oral rehydration salts; PNC, postnatalcare; prev, prevention; STI, Sexually Transmitted Infection; UN, Upper Nile; w, women; Warr, Warrap; WBeG, Western Bahr el Ghazal; WES, Western Equatoria.

improvement in delivery of the Basic Package of Health Services in four states including immunisation coverage, skilled birth attendance, use of insecticide-treated bednets, antenatal coverage, vitamin A supplementation, and tuberculosis case detection,[43] and galvanised stakeholders around common health service coverage goals and prioritised funding for these areas. It also intended to strengthen key MOH stewardship functions such as establishment of a management team to coordinate and monitor service delivery, organising monthly coordination meetings among the United Nations and bilateral agencies, NGOs, The World Bank and other development partners. It financed additional staffing, renovation, and equipped county-level health departments. It supported review and updating of the national health sector policy, and development of a 5-year Health Sector Development Plan (HSDP). It also introduced nationally, structured supervision of health facilities using supervisory checklists, developed health management information system (HMIS) tools and provided training on their use, and financed training of MOH staff on health management, information communication technology, and monitoring and evaluation. Further support came during 2011–2017 through the Health Rapid Results Project.[44–46] Further progress concerned health financing where health worker's salaries were harmonised and payrolls were screened to remove so-called 'ghost workers' who received salaries without working in the system. Although leadership and governance reportedly improved at the county level, trust between the government and international community had broken down due to political and ethnic tensions with open discrimination observed in the health sector.[42 47]

The human resource shortage in RSS continues to be dire with recent data showing the health system having <2 doctors and <20 nurses/midwives per 100 000 population compared with WHO's recommended 230 doctors, nurses/midwives per 100 000 population.[48 49] The MOH has attempted to strengthen HRH since 2012, by introducing task shifting, and prioritising front-line health workers for skills development.[50 51] The MOH has also tried to increase public health workers' salaries through an 'Infection Allowance' to be paid if county health departments implemented the Human Resources Information System.[52] Despite these efforts, the shortage of skilled health workers is still one of the biggest health sector challenges in RSS.[42] The MOH also introduced a routine HMIS,[42 53] and periodic LQAS household and health facility assessments to improve state and national health system management, to track health service delivery progress and to inform policy and action.[42] These efforts were supported by The World Bank and bilateral funding; improvements would not have been feasible without their partnership.

The development assistance for RSS before 2015, and health system improvements may have contributed to the positive trends we observed. For example, the increased use of institutional delivery, also reported by a qualitative study,[54] is associated with a 62% increase in the number of health facilities newly constructed from 1080 in 2011 to 1747 in 2016.[22 55] In 2011/2012, international donors agreed with the MOH on a new harmonised donor funding mechanism with three main donor programmes (The World Bank, US Agency for International Development (USAID) and Department for International Development (DFID)) supporting HSS and health service delivery in their assigned states. In addition to The World Bank's Umbrella Program for Health System Strengthening, five donors (Australia, Canada, the European Union, Sweden and the UK) provided funding through the Health Pooled Fund (HPF). HPF, which was managed by DFID, worked in six states on strengthening maternal, newborn and children health services during phase I (2012–2016).[56 57] USAID had a similar programme targeting two states.[47] These three donor programmes, with specific lead implementing partners assigned to each county, were commissioned to support the transition from an NGO-led to a government-led health service. Together they were to develop a county-based healthcare model. However, progress has been hampered by continued economic and political-military shocks. USAID and the two states they support joined HPF for phase II (2016–2018). HPF continues to support South Sudan through its phase III programme (2018–2023).[57]

Performance remained very low overall, much lower than global and regional averages and failed to meet HSDP targets with only one indicator (institutional delivery: 27%) achieving the 2015 HSDP target of 25%, a rate well below the 44% average reported for least developed countries.[50 58 59] The stagnation in ANC but improvements in measles vaccination coverage were corroborated by health facility assessments in RSS.[22 60] Nevertheless, RSS coverage is much lower than global and regional averages[6] and failed to meet HSDP targets.[50] ANC4+ was consequently stagnant as well remaining unchanged from 2010[18]; this deficiency was associated with geographic region, polygamy status, maternal literacy and knowledge of maternal danger signs. In 2014, UNICEF observed a decline in vitamin A supplementation, which rendered children more vulnerable to diarrhoea and measles especially in areas most affected by food scarcity.[61–64] Severe drug shortages linked to the termination of the Emergency Medicines Fund (EMF) in July 2015 and disruption in drug delivery, intensified the poor outcomes.[23 65 66] These events further indicate that the conditions and circumstances in which children and their mothers live play a role in understanding their morbidity and mortality.[19]

The low levels of service coverage also reflect South Sudan's fragility which after 20 years of war had minimal infrastructure.[50] Additional improvements are crucial given that armed conflict and environmental conditions in RSS favour outbreaks of measles, malaria and other infectious diseases.[67] The recently launched Boma Health Initiative (BHI),[43] a community-oriented health system initiative that seeks to improve access to health

promotion and disease prevention services at community level, is a step in this direction.[48 68] BHI organises health workers from the local community into health teams to provide primary healthcare services and is expected to further increase the access of people to the health system.[69 70] However, the success of the BHI depends on improved security of health workers and their communities, and stronger support systems for the decentralised health service delivery. It is also crucial that the MOH coordinates with international donors to ensure uninterrupted funding for medicines and health supplies, and to improve the management of drugs and supply chain logistics.[71 72]

### State-level performance

Progress was variable across the nine states. CES, where the capital city, Juba, is located, displayed the best performance for most indicators. While discussion of the variation of all indicators and states exceeds the scope of this paper, we present three examples below to highlight the importance of different socioeconomic, political, environmental and cultural factors for the interpretation of state-level results.

UN, in the north-east, is one of RSS's three oil-producing states and has the country's lowest poverty prevalence (26%) and highest literacy rate among 15–24 year-olds (65%) in 2009. However, from 2011 to 2015 it also had the most armed conflict events in RSS[73] including targeted attacks on health facilities.[66] The conflict events may explain why, in contrast to national results, the institutional delivery rate did not increase in UN, and was the lowest in RSS (13%, national range: 13%–55%) in 2015. The true coverage might be even lower, because armed conflict prevented us from accessing four of UN's 13 counties, including Malakal, which had been RSS's second largest city. Large parts of the city are now destroyed or looted, including the teaching hospital, one of only four in the country.[74] Despite the 2015 peace agreement, UN remained in a state of emergency with increased ethnic tensions, partly due to controversial plans to divide RSS's 10 states into 28 new states.[75]

The NBeG State in the north-west had RSS's highest poverty prevalence (76%) in 2009,[76] and the lowest female literacy (≤5%) in 2015. NBeG also had relatively few armed conflict events between 2011 and 2015,[73] possibly accounting for its increased rates of institutional delivery, malaria prophylaxis during pregnancy, malaria and diarrhoea treatments, and other indicators, corroborating positive trends observed by donors in 2014.[56] However, we found that the measles and diphtheria/pertussis/tetanus (DPT3) vaccination coverage had not increased in NBeG since 2011 and remained the lowest (measles: 27%, DPT3: 19%) in the country in 2015. Annual routine facility data from NBeG recorded a renewed positive trend after a steep decrease in vaccination rates during 2012.[77] It is possible that some health services are sensitive to contextual factors, displaying higher rates in some years and returning to lower levels at other points in time.

WES in the south-west had RSS's third lowest poverty prevalence in 2009[76] and the fewest conflict events between 2011 and 2015,[73] but RSS's highest HIV prevalence (6.8% in 2012). In our study, WES exhibited the highest rate for HIV testing and several other HIV and STI-related indicators, but surprisingly and conversely to the national trend deteriorated substantially for knowledge of HIV-related misconceptions, especially relating to witchcraft. Cultural beliefs in witchcraft are common among the Azande people living in WES; for many Azande the acceptance of messages about sexual HIV transmission does not necessarily contradict witchcraft lore.[78]

Our results show that national results often mask subnational inequities on state or lower levels. They underscore the importance of using methods that measure subnational variation and avoid the ecological fallacy that all subnational regions perform at the national mean.[79] We have not reported county-level LQAS classification results for reasons of space and to maintain a state-level analysis. Although county-level results are a strength of the LQAS method, and allow equity-sensitive tracking of progress,[23] we chose a state-level analysis to maintain a higher level health system focus for this research. LQAS typically uses relatively small sample sizes and is administered locally mostly by public sector or NGO health workers, which enabled us to conduct a national survey under very challenging circumstances that impeded implementation of other national surveys, such as the MICS. Further, social desirability and recall bias might have led to over-reporting or under-reporting of some coverage indicators, which is a common limitation for surveys that assess self-reported behavioural data. Our results may not reflect the situation in internally displaced population camps, which can be assessed by separate LQAS studies, as shown elsewhere.[80]

Other organisational factors also play a role. Part of the subnational variation might be explained by the differing performance of implementing organisations and the varying types of private and public providers, which may vary for some of the indicators.[81 82] However, comparing the quality of different provider types is a complex study and context dependent, and exceeds the scope of our study. Also, the political situation in South Sudan is volatile, and geographical areas of conflict can shift rapidly which may lead to changes in future subnational results.[83] Our national-level results may also not be easily generalised to other conflict-affected countries, as the political environment and nature of civil war can be extremely complex and context dependent.[84]

Despite these limitations, our results demonstrate progress in HSS in a country with protracted conflict. This conclusion contradicts the common notion that 'war is development in reverse'.[4] Our findings coincide with a recent report that under-five mortality rates declined during the majority of wars fought between 1970 and 2008.[85] While we do not measure mortality, we do measure the improved health services associated with

such declines. The public health policies made during peacetime South Sudan and international donor support created a momentum for improving infrastructure during wartime. Even though much support to RSS has been humanitarian aid, broader HSS has been evident. In Afghanistan, for example, the substantial increase in international humanitarian and development aid after the overthrow of the Taliban in 2001 allowed progress in education and MNCRH despite ongoing conflict.[86 87] South Sudan may display a similar pattern.

National surveys using the decentralised approach presented here provided valuable information for county, state and central-level health system managers to identify priority health interventions needing improvement. Managers valued it at each level of the health system because the data aided them to know the condition of their own programmes, rather than only the average value of an indicator at a national or regional level. Previous research has shown that the values of an indicator can vary substantially within a region.[79] While these data are valued in the health system, the frequency with which they are collected is context specific. Although some countries are carrying out these surveys semiannually,[88] others do so annually or biennially.[89] Fragile countries experiencing conflict may have longer intervals due the higher costs and logistical challenges of carrying out a national survey in a humanitarian setting.

## CONCLUSIONS

Our results documented moderate improvement in several key indicators: institutional delivery, immunisations, malaria prophylaxis during pregnancy, malaria and diarrhoea treatment, and HIV testing. They demonstrated that a health system can strengthen during a protracted conflict. However, in 2015, the baseline year for the SDGs, RSS was still far from achieving national and international targets for these and other services. Since 2015, the instability in RSS has persisted due to domestic political-military conflict. Without continued international support, health system improvement could be threatened and health service delivery would deteriorate, as seen with the widespread stock-outs of essential medicines after the termination of the EMF.[56 65] Donors need to carefully coordinate development aid for HSS with parallel humanitarian aid so they are mutually supportive.[42 90] The collective concerted efforts of international and national stakeholders are required so that the measurable gains in South Sudan are not threatened and the world's newest and most fragile country is supported on its ambitious path towards sustainable development.

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**Contributors** JJV, RL: conception of the research. JJV, RL, WV, BD: acquisition of data. JJV, CJ, SB: analysis. JJV, SB, BD, JO, RL: interpretation of data. JJV, SB, JO: drafting the paper. All authors were involved in critical revision of the content, approval of the final manuscript and were accountable for all aspects of the work.

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**Patient consent for publication** Not required.

**Ethics approval** The ethical committees of the MOH for the Republic of South Sudan and the authors' home institution approved the protocol, study instruments and consent procedures. We obtained oral rather than written informed consent from all respondents, because of the high illiteracy rate.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon request. With permission from the Ministry of Health of the Republic of South Sudan, LSTM will then make an anonymised version of the two data sets available on the LSTM's Online Research Archives available at https://archive.lstmed.ac.uk/ under a creative commons licence.



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