

Impact of supplemental immunisation activity (SIA) campaigns on health systems: findings from South Africa

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ABSTRACT

Background Supplemental immunisation activity (SIA) campaigns provide children with an additional dose of measles vaccine and deliver other child health interventions including vitamin A supplements, deworming medications and oral polio vaccines. They also require the mobilisation of a large health workforce. We assess the impact of the implementation of SIA campaigns on selected routine child and maternal health services in South Africa (SA).

Methods We use district-level monthly headcount data for 52 South African districts for the period 2001–2010, sourced from the District Health Information System, SA. The data include 12 child and maternal health headcount indicators including routine immunisation, and maternal and reproductive health indicators. We analyse the association between the implementation of the 2010 SIA campaign and the change (decrease/increase) in headcounts, using a linear regression model.

Results We find a significant decrease for eight indicators. The total number of fully immunised children before age 1 decreased by 29% (95% CI 23% to 35%, $p < 0.001$) during the month of SIA implementation; contraceptive use and antenatal visits decreased by 7–17% ($p \leq 0.02$) and about 10% ($p < 0.001$), respectively.

Conclusions SIA campaigns may negatively impact health systems during the period of implementation by disrupting regular functioning and diverting resources from other activities, including routine child and maternal health services. SIA campaigns present multidimensional costs that need to be explicitly considered in benefit–cost assessments.

INTRODUCTION

The WHO strategy to reduce measles mortality includes maintaining high coverage for routine measles immunisation and ensuring all children receive a second vaccine dose.¹ In high-income countries, a second dose is usually included in the routine vaccination schedule and is commonly administered to children before school entry. In the majority of low-income and middle-income countries, the second dose of measles vaccine is offered largely through supplemental immunisation activities (SIAs).^{1–2} First introduced and implemented by the Pan American Health Organization in the 1990s, periodic SIA campaigns have occurred nationally or subnationally in the Americas with the use of diverse outreach strategies,² and are thought to have facilitated the elimination of measles transmission in the region.³ A similar

strategy has been imported to sub-Saharan Africa over the past decade, and is now similarly believed to be responsible for significant reductions in measles mortality in Africa.^{4–5} In these settings, SIAs provide children aged 6 months–14 years with a second dose of measles vaccine during campaigns that last a few days to a few weeks.⁶

SIAs can incorporate the delivery of other child interventions including vitamin A supplementation, deworming medicines, oral polio vaccines and insecticide-treated bed nets (ITNs).⁷ In countries such as Ethiopia or Zambia, the SIAs are integrated into periodic ‘Child Health Days’.⁸ In particular, ITNs have been distributed through these campaigns⁹ in malaria-endemic countries. Since 1996, South Africa (SA) has implemented SIAs within the polio national immunisation days at the provincial level.¹⁰ Until 2012, the South African campaigns delivered vitamin A supplements, deworming medicines and oral polio vaccines, in addition to the measles vaccine. For those with access, these health interventions are also available at routine primary healthcare visits.

SIAs are utilised as an important component of measles elimination. Although questions about the possible negative effects of mass campaigns on routine services have been raised,¹¹ to date analysis of the impact of SIAs on health systems remains scarce.^{12–13} Low-income and middle-income countries including SA face an acute shortage of health workers, with issues of absenteeism, high vacancy rates and inequitable distribution of the workforce between rural and urban settings.^{14–17} In this context, we examine the impact of the SIA held in 2010 on selected health services in SA, with the goal of identifying whether SIAs impair health system functioning by diverting the health workforce from accomplishing routine duties when directed to work on the SIA campaigns.

METHODS

SIAs are conducted in SA every 3–4 years.¹⁸ The 2010 SIA was a national campaign operated in all provinces by each provincial department of health during 3 weeks. Measles vaccines were delivered to children aged 6 months–14 years, oral polio vaccines to children under five, and vitamin A supplements and deworming medicines to 12-month-olds to 59-month-olds. Further detail is provided in the online supplementary appendix (section 1).

SIAs utilise health workers predominantly from district-level primary healthcare clinics. The impact of SIA implementation on health systems can be

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measured empirically while looking at district-level activity using headcount data (ie, number of patient visits) for specific services, before, during and after SIA implementation, following the general approach of interrupted time-series (ITS).¹⁹ ITS studies use data collected at defined intervals of time, do not require a control site, and provide a robust method of measuring the effect of an intervention being implemented at a precise point in time, in the absence of randomisation.¹⁹ This approach is well suited to the monitoring and evaluation of health policies. We use district-level monthly headcount data for the 52 South African districts sourced from the District Health Information System (DHIS), SA, for the decade 2001–2010. A complete list of all districts is given in the online supplementary appendix (section 2).

The DHIS is a national health information system. It is an open-source management information system developed by the Health Information Systems Programme (HISP). It covers aggregated routine and semipermanent data (staffing, equipment, infrastructure, population estimates), survey/audit data and certain types of patient-based data (eg, disease notification). The system captures data at any hierarchical level, any collection frequency, and offers a high degree of customisation at the input and the output side. Data flow from facility level to subdistrict to district to province to national level. Every health facility in every district reports on the DHIS. Health facilities complete monthly tally sheets that are submitted to information officers in subdistricts/districts where they are captured electronically. Where the capacity exists (eg, hospitals), the data are captured electronically. The data are eventually aggregated and summarised in publications.^{20 21}

The longitudinal data we use include the total number of patients visiting a health facility for a specific service, in each district, during the reporting period (each month, from January

through December, during 2001–2010). Each patient is counted for each service she/he uses at the facility. The data we use are constituted from a range of child and maternal health headcount indicators (HIs; table 1). Six of these are child health indicators, including three for immunisations (first and second doses of routine measles vaccine, number of children having fully completed a primary course of immunisation before age 1); and three for general child health (number of under-5 children weighed, number of primary care facility visits for children under and above 5). There were also six maternal health HIs. These include three reproductive health indicators (number of oral contraceptives packets, and number of two different injectable contraceptives, given to women aged 15–44) and three antenatal care indicators (number of first and follow-up antenatal visits, number of in-facility deliveries under the supervision of trained medical staff). As an illustration, we show the monthly number of children under age 1 who have completed a primary course of immunisation, from January to November 2010, in the district of Cape Town Metropolitan Municipality (figure 1).

We analyse the association between the implementation of the 2010 SIA (held from 12 April to 7 May 2010) and the change (decrease/increase) in activity, measured by the HIs. For each HI, each year t of 2001–2010, and each district d , we extract the headcount numbers for March and April, $\text{March}_{\text{HI},d,t}$ and $\text{April}_{\text{HI},d,t}$, and their relative difference $\Delta_{\text{HI},d,t} = \text{March}_{\text{HI},d,t} - \text{April}_{\text{HI},d,t}$. We use the model:

$$\Delta_{\text{HI},d,t} = \beta_0 + \beta_1 \text{March}_{\text{HI},d,t} + \beta_2 \text{Year}_t + \beta_3 \text{March}_{\text{HI},d,t} \text{Year}_t + \beta_d + e_{d,t} \quad (1)$$

$\text{Year}_t = 1$ when $t = 2010$, 0 otherwise, β_d is a district random effect, $e_{d,t}$ an error term. β_1 controls for seasonal effects, as some changes

Table 1 Headcount indicators: monthly numbers of primary healthcare visits at the district level, that is, the total number of patients visiting a health facility for a specific service, each month, in each district

Headcount indicator name	Headcount indicator description	Reporting unit	Reporting time period
PHC under 5	Total number of patients under 5 visiting a facility for primary healthcare	District-level health facility	Monthly, from January 2001 to November 2010
PHC above 5	Total number of patients above 5 visiting a facility for primary healthcare	District-level health facility	Monthly, from January 2001 to November 2010
Weight under 5	Total number of children under 5 weighed	District-level health facility	Monthly, from January 2001 to November 2010
MCV 1	Total number of children under 1 immunised with the first dose of routine measles vaccine	District-level health facility	Monthly, from January 2001 to November 2010
MCV 2	Total number of children above 1 immunised with the second dose of routine measles vaccine	District-level health facility	Monthly, from January 2001 to November 2010
Immunised	Total number of children who have completed a primary course of immunisation before age 1	District-level health facility	Monthly, from January 2001 to November 2010
Oral pill cycle	Total number of packets of oral contraceptives issued to women aged 15–44	District-level health facility	Monthly, from January 2001 to November 2010
Medroxy acetate	Total number of Medroxyprogesterone acetate injections given to women aged 15–44	District-level health facility	Monthly, from January 2001 to November 2010
Nore enanthate	Total number of Norethisterone enanthate injections given to women aged 15–44	District-level health facility	Monthly, from January 2001 to November 2010
Antenatal 1	Total number of first antenatal visits	District-level health facility	Monthly, from January 2001 to November 2010
Antenatal FU	Total number of follow-up antenatal visits	District-level health facility	Monthly, from January 2001 to November 2010
Delivery	Total number of deliveries in facility under the supervision of trained medical nursing staff	District-level health facility	Monthly, from January 2001 to November 2010

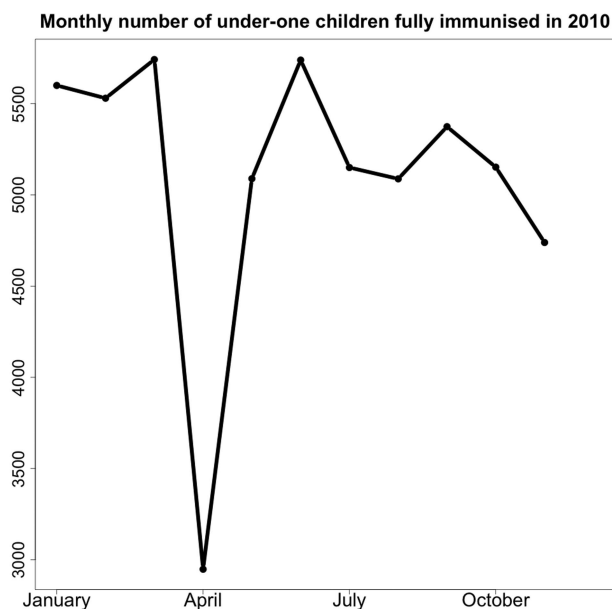


Figure 1 Monthly number of children under age 1 who have completed a primary course of immunisation from January to November 2010, in the district of Cape Town Metropolitan Municipality.

may vary at certain regular times (between the months of March and April here) independently of other factors. β_2 controls for potential non-stationarity effects due to the 2010 year (independent of the SIA). β_d controls for district-level variations, including the headcount baseline level. β_3 's prospective significance would indicate an increase/decrease in the HI associated with the 2010 SIA implementation. The total number of observations is 515: 52 districts reported data over 10 years (2001 through 2010) and there were five missing years (2001 through 2005) for the uMgungundlovu DM district. All analyses were conducted with R statistical package (<http://www.r-project.org>).

RESULTS

Table 2 exhibits summary measures for each monthly HI examined. It shows the median and IQR, across the districts, for the relative difference in the number of patient visits between the months of March and April $\left(\frac{\text{April}_{\text{HI,d,t}}}{\text{March}_{\text{HI,d,t}}} - 1\right)$, for the aggregate time period 2001 through 2009, and the single year 2010. For 2001–2009, for each HI, the IQR of the relative difference between the months of March and April spans 0. In 2010, this relative difference demarcates itself from the aggregate value 2001–2009. The median relative difference presents a strictly negative IQR for three child health indicators (the first and second doses of routine measles vaccine, and the total number of fully immunised children under age 1), and for two maternal health indicators (the total numbers of first and follow-up antenatal care visits). Specifically, from 2001–2009 to 2010, the first and second doses of routine measles vaccine, the total number of fully immunised children under age 1, and the total number of first antenatal care visit all show substantial decreased median relative difference (inferior to 0.10). In the meantime, a few HIs (eg, total number of primary healthcare visits for children under and above 5, total number of in-facility deliveries under the supervision of trained medical nursing staff) still present an IQR spanning 0 in 2010, and show little decrease

Table 2 Relative difference (median and IQR) in the number of patient visits between the months of March and April, across districts, for each headcount indicator: over the period 2001–2009 and over the single year 2010

Headcount indicator	Median relative difference (IQR in parentheses), across districts, in the number of patient visits between the months of March and April	
	2001–2009	2010
PHC under 5	−0.02 (IQR: −0.09; 0.04)	−0.03 (IQR: −0.17; 0.00)
PHC above 5	−0.02 (IQR: −0.07; 0.03)	−0.06 (IQR: −0.11; 0.01)
Weight under 5	−0.03 (IQR: −0.11; 0.05)	−0.13 (IQR: −0.21; 0.00)
MCV 1	−0.03 (IQR: −0.12; 0.05)	−0.29 (IQR: −0.41; −0.05)
MCV 2	−0.07 (IQR: −0.15; 0.06)	−0.29 (IQR: −0.43; −0.07)
Immunised	−0.05 (IQR: −0.11; 0.05)	−0.33 (IQR: −0.44; −0.20)
Oral pill cycle	0.05 (IQR: −0.05; 0.15)	−0.03 (IQR: −0.17; 0.05)
Medroxy acetate	0.06 (IQR: −0.02; 0.14)	0.00 (IQR: −0.06; 0.06)
Nore enanthate	−0.03 (IQR: −0.10; 0.04)	−0.11 (IQR: −0.19; 0.01)
Antenatal 1	−0.02 (IQR: −0.12; 0.08)	−0.16 (IQR: −0.19; −0.09)
Antenatal FU	−0.01 (IQR: −0.08; 0.06)	−0.09 (IQR: −0.14; −0.01)
Delivery	−0.03 (IQR: −0.07; 0.02)	−0.05 (IQR: −0.08; 0.01)

The complete description of each headcount indicator is given in table 1. There are 52 districts, hence there are, for the relative difference between March and April, 463 observations for 2001–2009 (five missing years for the uMgungundlovu DM district), and 52 for the year 2010.

(between 0.05 and 0) between 2001–2009 and 2010. Indeed, the evolution over 2001–2010 of the relative difference in the number of patient visits between the months of March and April for in-facility deliveries clearly contrasts with that for children completing a primary course of immunisation before age 1 (figure 2).

Table 3 analyses the association between the SIA implementation and HIs at the district level, giving the effect sizes (β_3 in (1) above) for the different HIs and their prospective significance. Eight of the 12 indicators studied showed significant decreases ($p < 0.05$) during the SIA campaign. Two immunisation indicators showed a significant decrease: (1) the first dose of measles vaccine (13%) and (2) the total number of fully immunised children before age 1 (29%). During the campaign, the total number of children under 5 who were weighed decreased by 8%. The three remaining child health indicators (second dose of measles vaccine, total number of primary care visits for children under and above 5) did not show a statistically significant change ($p > 0.05$) in activity during the month of SIA implementation. There was a statistically significant decrease in all three reproductive health indicators with decreases ranging from 7% to 17%. During the SIA, there was also a relative decrease in activity for two antenatal care indicators: 12% reduction for the first antenatal care visit and 11% reduction for the antenatal care follow-up visit. Finally, one maternal health indicator, that is, the total number of in-facility deliveries under the supervision of trained medical nursing staff did not show any statistically significant changes.

DISCUSSION

The 2010 SIA in SA was associated to a significant decrease in the use of child and maternal health services at the district level during the month of the campaign. During its implementation, we found fewer children completed their primary course of routine immunisation, received the first dose of routine measles vaccine and were weighed, and fewer women used

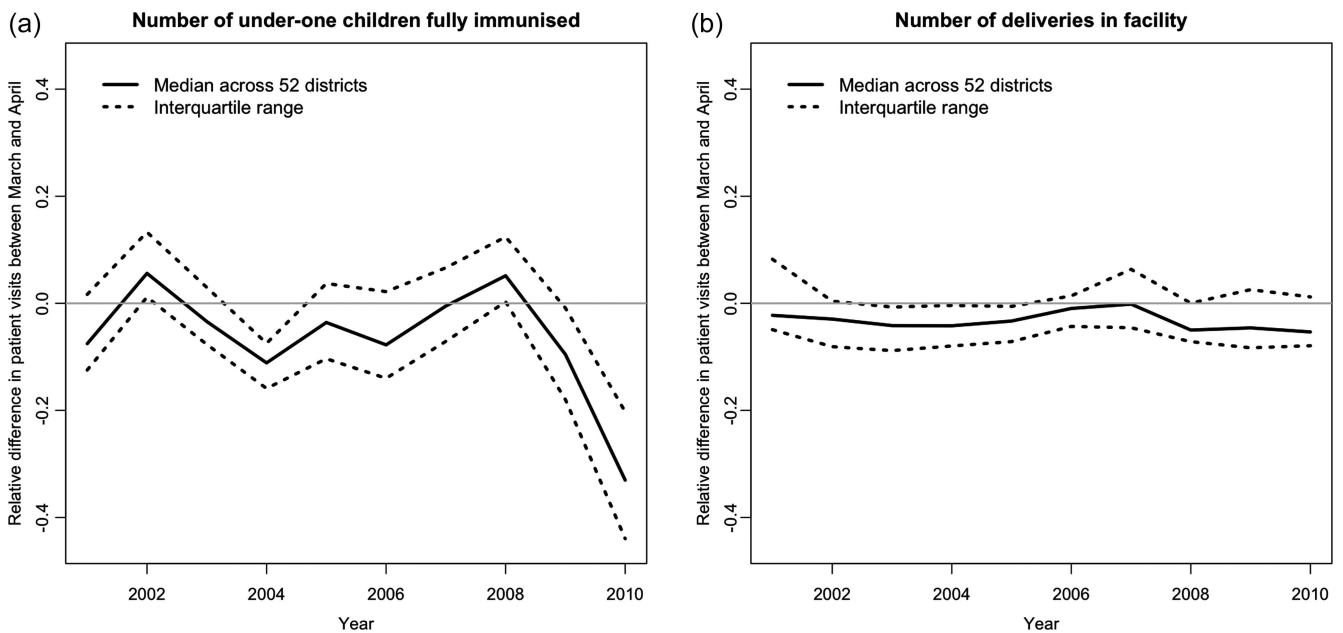


Figure 2 Relative difference in the number of patient visits between the months of March and April for the period 2001–2010 for: (A) the number of children under 1 who have completed a primary course of immunisation, (B) the number of deliveries in facility under the supervision of trained medical nursing staff.

reproductive health services and sought antenatal visits, at the district level (table 3).

Some possible interpretations include the following. The decrease in routine delivery of some immunisations may have been partially compensated for by increases during campaign implementation or by an increased use of routine services in the months following SIA. In this respect, there may be shifting and rescheduling of specific visits from the SIA period to after SIA, potentially bringing greater efficiency. Yet, decrease in routine coverage was observed during immunisation campaign years in a number of countries.^{18 22 23} Additionally, the decrease in antenatal visits and under utilisation in contraceptive services would have been difficult to compensate for in subsequent months. Furthermore, the unchanged routine delivery of the second dose of measles vaccine may be due to SIA immunisations being

recorded as routine immunisations, and the unchanged number of primary care visits may indicate that primary headcount visits included campaign immunisation visits during campaign implementation. Finally, the unchanged number of in-facility deliveries may point to the robustness of our findings as, expectedly, emergency and delivery services would not be affected by SIA.

Our study takes a quantitative approach, whereas most research to date has provided qualitative findings. The acute decrease in some child and maternal health indicators we highlight suggests that SIA campaigns may negatively impact the South African health system. Our findings are consistent with previous work¹⁸ which also pointed to the decrease in routine coverage for some vaccines in SA during the years SIAs were implemented. Likewise, national routine immunisation rates decreased in the first years following the introduction of the national immunisation days in 1996 in Southern Africa.²² SIA campaigns may undermine the WHO objective of sustaining high coverage of routine immunisation including measles.¹ Comparatively, studies on the impact of polio eradication on routine immunisation services found a non-improvement or a decrease in some places (eg, sub-Saharan Africa, South Asia),²³ though strengthening of routine delivery was shown in other places (eg, Western Pacific)²⁴ and measles elimination activities were not associated with a decrease in national routine immunisations in particular years with SIAs in six low-income and middle-income countries.¹² Our findings support those from Cameroon and Ethiopia showing that SIA campaigns may negatively impact health systems.¹² Notably, SIAs may interfere with the delivery of other services, which may be interrupted because of staff shortages,¹² such as the maternal and child health services we examine here. This evidence reinforces the suggestion that SIAs may affect routine services.²⁵ Mass immunisation campaigns may not only promote the development of health systems, but may also disrupt regular functioning and divert resources from other activities.^{26 27} This is especially critical in SA, where the substantial shortage of human resources for health and their maldistribution has compromised the delivery

Table 3 Results of the linear regression model measuring the association between the implementation of the 2010 supplemental immunisation activity campaign and the change (decrease/increase) in monthly headcount indicators at the district level

Headcount indicator	Effect size	95% CI	p Value
PHC under 5	0.05	-0.01 to 0.12	0.08
PHC above 5	-0.02	-0.04 to 0.02	0.45
Weight under 5	-0.08	-0.12 to -0.03	<0.001
MCV 1	-0.13	-0.21 to -0.06	<0.001
MCV 2	-0.04	-0.15 to 0.08	0.51
Immunised	-0.29	-0.35 to -0.23	<0.001
Oral pill cycle	-0.07	-0.13 to -0.01	0.02
Medroxy acetate	-0.12	-0.16 to -0.07	<0.001
Nore enanthate	-0.17	-0.21 to -0.14	<0.001
Antenatal 1	-0.12	-0.18 to -0.07	<0.001
Antenatal FU	-0.11	-0.14 to -0.07	<0.001
Delivery	0.04	-0.01 to 0.08	0.10

of key child and maternal health interventions.¹⁷ The number of health staff varies widely between districts with the percentage of doctors and nurses being 10% and 60%, respectively, of what they should be.¹⁶

The data we use present several limitations. First, administrative data can reflect weaknesses in monitoring systems and measurement errors,²⁸ and probably overlook the vaccinations carried out in the private sector which are not directly reported to the national department of health. Second, data quality challenges still exist despite the DHIS. The predominantly paper-based system of data collection, coupled with the lack of electronic information systems has resulted in non-standardised records in use in primary healthcare facilities. Staff for data capture are inadequate, despite a national training programme. There is also a lack of data review at facility and district levels, and poor prioritisation in the use of quality data for planning.

Our results have important implications for South African decisionmakers. SA faces a heterogeneous disease burden, with the dual epidemic of HIV and tuberculosis and the growing epidemic of non-communicable disease and injury.²⁹ Mobilising human resources to mount SIAs may not be the best allocation of scarce resources. However, other kinds of reasons may be offered to justify SIAs. For example, polio and measles vaccinations may be considered global goods in the context of elimination/eradication initiatives. In addition, routine activities rarely achieve universal coverage in a population, especially when the population is diverse and remote rural areas are difficult to reach. SIAs can reduce coverage heterogeneity and may be required to achieve equitable access to basic child health services.^{30–32} SIAs may also be cost-effective,^{33–35} and can be used as a delivery platform for other maternal and child health interventions.^{9–36} Finally, SIAs can bring diversified training opportunities and lead to aspirational fulfilment for health workers, when directed to work on the SIA campaigns and serve marginalised populations in remote areas.

In the future it would be useful to measure the specific impact on other routine services. For example, data on the utilisation of selected services that impact child mortality such as consultations specific to diarrhoea and pneumonia would be important. The full 'opportunity costs' of SIAs could then be considered by policymakers when selecting interventions in resource-constrained settings, costs which should be taken into account in the broader context of benefits and costs of SIAs. This study provides evidence of the need for an approach to designing child health delivery platforms that acknowledge and can potentially lower 'opportunity costs'. Analyses of this kind enable a comparison of tradeoffs between distinct health system delivery platforms, such as mass immunisation campaigns compared with routine immunisation services. In particular, there may be a transitional point when a particular country opts to move away from mass immunisation campaigns towards strengthening its routine immunisation services.

Our approach could be used by other low-income and middle-income countries currently implementing SIA campaigns, utilising context-specific data in order to provide context-specific analyses. The methodology implemented here may require quality data of the primary headcount type that exists in SA. However, the DHIS, originally developed for three districts in Cape Town in the late 1990s, has since spread via the HISP network to nearly half of sub-Saharan Africa, covering a population of 300–400 million people at different subnational levels, and to a number of Asian countries. Using this network, our analysis could be reproducible in other countries, provided the existence of similar longitudinal headcount data on health

services, such as time series on the utilisation of selected services at facility/district level that impact child mortality.

What is already known on this subject

- ▶ Supplemental immunisation activity (SIA) campaigns provide children in low-income and middle-income countries with measles vaccines and other health interventions, which require mobilising a large workforce during their implementation. To date, there has been little analysis of the impact of these mass campaigns on health systems, and the possibility of negative effects on routine health services remains poorly explored.

What this study adds

- ▶ This study examines the impact of SIA held in 2010 on selected health services in South Africa, using district-level monthly headcount data. During the month of SIA implementation, the total number of immunisations, contraceptive dispersal and antenatal visits decreased substantially. SIA campaigns may negatively impact health systems during the SIA mass immunisation campaigns by disrupting regular functioning and diverting resources from other activities.
- ▶ During the period of the 2010 SIA campaign, there was a decrease in the children fully immunised under one in South Africa.
- ▶ The 2010 SIA campaign led to a decrease in the contraceptive use and antenatal visits in South Africa.
- ▶ SIA campaigns may negatively impact health systems by disrupting regular functioning and diverting resources from other activities.

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Contributors SV, WJ and KJH initiated the study. SV and WJ coordinated the research and did the analysis with MYB. SMT, CJLM and DTJ reviewed the paper and provided advice and suggestions. SV wrote the manuscript. WJ, MYB, KJH and SMT edited the manuscript.

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