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Costs of childhood vaccine delivery in Iraq: a cross-sectional study

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ABSTRACT

Objectives In recent years, Iraq has expanded and revised the childhood immunisation schedule, but estimates of the costs of the programme are unavailable. The objective of this study was to estimate the economic costs of delivering childhood vaccines in Iraq from a government perspective.

Setting Health facilities were sampled using multistage probabilistic sampling and stratifying the country into three regions: Central and South, North/Kurdistan Region, and Retaken Areas. Cost data were collected from 97 health facilities and 44 district and regional vaccine stores. Total national costs were extrapolated using sample weight calibration.

Participants Administrators at each health facility and vaccine store were interviewed using a standardised survey.

Primary and secondary outcome measures Total costs of vaccine delivery per year, costs per dose delivered and delivery costs per fully vaccinated child.

Results An estimated 15.3 million vaccine doses were delivered in 2018, costing US$99.35 million, excluding costs of vaccines and injection material. Nearly 90% of delivery costs were attributed to personnel salaries. Vaccine record-keeping and management (21%) and facility-based vaccine delivery (19%) were the largest cost contributors. Vaccine transport and storage, programme management, and outreach services represented 13%, 12% and 10%, respectively. All other activities represented less than 10% of the total cost. Average costs per dose delivered was US$6.48, ranging from US$9.13 in Retaken Areas to US$5.84 in the Central and South. Vaccine delivery costs per fully vaccinated child totalled US$149.

Conclusion This study provides baseline evidence of the current programme costs and human resource uses which can be used for annual planning, identifying areas for improvement, and targeting strategies to increase programme efficiency.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Primary data on resource use were collected from a representative sample of health facilities and vaccine stores.
⇒ Human resource costs were estimated from interviewing health workers and administrators on the amount of time spent on different activities.
⇒ Differences in vaccine delivery costs according to distinct settings within Iraq were presented.
⇒ The main limitation is that the delivery costs represent current practice and not how much it would cost to increase vaccination coverage or improve quality of services. In addition, data availability and quality varied between facilities, requiring assumptions when extrapolating across facilities.

INTRODUCTION

The COVID-19 pandemic has been a stark reminder of the value of vaccines, with the novel vaccines against SARS-COV-2 widely considered as the only feasible tool to control the pandemic. Decades of evidence show that vaccines save lives and prevent morbidity from both common and rare diseases. Globally, measles vaccine reduced childhood measles deaths by 73% between 2000 and 2018 and wild polio virus has been eliminated in all but two endemic countries.[1] Over the last decade, efforts to introduce new vaccines, like the pneumococcal conjugate and rotavirus vaccines, in a timely manner in low-income and middle-income countries have contributed to saving more lives than ever before.[2] The economic benefits of immunisation include savings in treatment costs, productivity lost to illness and caregiving, and lifetime earnings lost from premature death and disability. A recent analysis yielded a potential return on investment of US$19.8 per US$1 invested for a group of 94 low-income and middle-income countries against 10 antigens over the period 2021–2030[3]. However, the full benefit of vaccines is only achieved if countries can deliver vaccines routinely and optimally to their populations.

Iraq is an upper-middle income country with a population of nearly 40 million and US$5955 GDP per capita in 2019.[4] The number of live births were approximately 1.2 million in 2018.[5] The Expanded Program on Immunization (EPI), which includes routine immunisations, campaigns and surveillance of vaccine preventable diseases, was introduced in Iraq in 1985. With the support of UNICEF and the WHO, the EPI expanded from oral polio vaccine, diphtheria-tetanus-pertussis

(DTP), hepatitis B, measles and measles-mumps-rubella to include *Haemophilus influenzae* type b containing combination vaccines, inactivated polio vaccine, rotavirus and 13-valent pneumococcal conjugate vaccine (PCV13), with the most recent change in the schedule made in 2019.[6]

Conflict and violence within Iraq and in neighbouring Syria throughout most of the last two decades, along with an influx of Syrian refugees, has resulted in continued outbreaks of vaccine preventable diseases. In addition, rolling electrical outages and inconsistent maintenance of the immunisation delivery system during conflict have been associated with declining vaccination coverage rates and an increase in disease outbreaks. Despite these challenges, the EPI has achieved substantial success in the past few years. Coverage of DTP3 increased from 68% in 2015 to 84% in 2019. Similarly, coverage of the second dose of measles containing vaccine increased from 76% in 2015 to 86% in 2019.[7] However, routine vaccination still lags behind other countries in the Middle East and in North Africa where coverage for most vaccines exceeds 90%. Coverage in Iraq remains low for newer vaccines like PCV13 (37%) and rotavirus (60% in 2018) due to frequent stock outs, and the 2018 Multiple Indicator Cluster Survey found only 46.9% of children 12–23 months were fully vaccinated as per the Iraq vaccination schedule.[8]

Although efforts have focused on strengthening the vaccine supply chain, large disparities among rural versus urban and socioeconomic status remain across the Iraqi governorates. Vaccine coverage varies considerably across governorates, with the proportion of fully vaccinated children (FVC) ranging from 14% in Nainawah to 79% in Sulaimaniya in 2018; with South and Central Iraq worse off than the Kurdistan Region of Iraq (KRI). Similarly, the proportion of FVC in urban areas was 51% in 2018 compared with only 38% in rural areas, and coverage in the poorest wealth quintile was about 30% less than the richest quintile.[8]

Routine immunisation activities are primarily delivered at primary healthcare (PHC) centres and subcentres, but these facilities continue to be impaired due to years of conflict. Only 56% of PHC centres provide immunisation services, and several provide these services in facilities damaged by 20 years of conflict. Since 2018, Iraq's EPI has undergone extensive review. Leaders from UNICEF and WHO have completed a thorough Effective Vaccine Management review with most districts reporting 80% efficiency across multiple markers, such as cold chain supply, staff training and delivery of vaccines.[9] The present study is a component of the review of the EPI, aiming to support policy decisions on immunisation in Iraq by estimating the cost of routine vaccine delivery through the National Immunization Program and assess regional differences in delivery costs. Combined with the other evaluations of the EPI, the estimates from this study can provide decision makers with information needed to make changes to the EPI programme.

METHODS

We retrospectively estimated the economic cost of the childhood immunisation programme in Iraq from the government perspective using the common approach for costing immunisation services developed by the Expanded Program of Immunization Costing (EPIC) project.[10 11] Data on personnel time and resources spent on immunisation programme activities were collected from sampled public health facilities and vaccine stores.

Table 1 Activities included within cost categories

Cost category	Included activities
Facility-based vaccine delivery	► Administering vaccines to children at a health facility
Outreach services	► Travel to and from outreach sites to administer vaccines
Vaccine distribution and storage	► Collection of vaccines at the central level ► Transport of vaccines to subnational stores and health centres ► Storage of vaccines at central and subnational stores
Record keeping, monitoring and evaluation	► Maintaining stock registers ► Maintaining records of vaccinated children ► Data entry, report and analysis preparation ► Monitoring and evaluating the immunisation programme
Supervision	► Oversight of subordinate personnel at each level
Training	► Immunisation related training at the central level, excluding campaign activities
Community mobilisation	► Holding community meetings ► Printing educational materials ► Conducting sensitisation activities in the community
Cold chain maintenance	► Fuel and resources to maintain the cold chain at all levels
Programme management	► Planning activities ► Budgeting ► Management of the immunisation programme at all levels

The immunisation programme includes nine cost components as summarised in table 1. Vaccination campaigns, vaccination of at risk or adult populations, and surveillance activities were not included in the analysis.

Health facilities providing immunisation services were stratified by subnational region:

- *Central and South:* Babel, Baghdad, Basrah, Dewanieh, Diyala, Karbulaa, Missan, Mouthanna, Najaf, Thiqar and Wasset governorates.
- *North/KRI:* Duhok, Erbil, and Sulaimanieh governorates.
- *Retaken Areas:* Anbar, Karkouk, Ninawa, and Sallaheddin governorates.

The sample of health facilities was randomly selected using a multistage probabilistic sampling approach stratified by region. Directorates from each region were sampled in the first stage, followed by districts in the second stage, and lastly, health facilities in the third sampling stage. Using a sampling frame of all 1719 PHC Centers and PHC Sub-Centers providing routine immunisation services, directorates were sampled using simple random sampling, and districts and health facilities were sampled using probability proportional to size based on the catchment population under-one. Health facilities were further stratified by PHC Center and Sub-Center to account for differences in cost by facility size. PHC centres are in urban or semiurban areas and are staffed by one or more physicians as well as nurses, other medical personnel, and administrative staff. PHC subcentres are in rural areas and primarily staffed by non-physicians. For facilities where the catchment population under-1 year was unavailable (n=60), the average population for other facilities of the same type in the region was used.

The sampling was performed using the Sample Design Optimizer (SDO) tool developed by the EPIC Project at the Harvard T.H. Chan School of Public Health to maximise precision with study budget constraints.[12] To evaluate the sample precision, the SDO required estimates on expected cost of vaccine delivery for each facility type. The SDO runs millions of simulations of sample selections from the possible study designs based on the design constraints and calculates the expected precision.[12] No data on the approximate cost of vaccine delivery were available for Iraq, so for the sampling, estimates of the cost of vaccine delivery in Honduras were used as a proxy.[13] See the online supplemental appendix for additional information on the sampling strategy. A total of 97 facilities (73 PHC Centers and 24 PHC Sub Centers) were sampled, and relevant distribution stores at the district and directorate of health (DOH) level along with the national vaccine store were also included. Table 2 summarises the number of facilities and vaccine stores sampled in each region.

Data were collected from health workers and administrators at each facility and stores using a standardised survey adapted from the EPIC health facility survey, which has been validated and used in several settings.[14] The survey was adapted for each level of the health system to ensure that data on all relevant costs and outputs were collected. Data on resource use were collected for capital and recurrent cost categories, including (1) cold chain equipment, energy, and maintenance; (2) vehicles, fuel, maintenance, and transportation fares; (3) buildings and maintenance; (4) personnel salaries, per diems, and allowances; (5) training; (6) community mobilisation; (7) utilities and communication; (8) waste disposal; (9) office equipment and supplies; (10) printing of immunisation cards, training materials, and information, education and communication materials. At the facility level, data on the catchment population (birth cohort, children under-1, and children under-5), frequency of outreach activities, doses administered and vaccine coverage in 2018 were collected. Prior to data collection, the survey tool was translated into Arabic and pretested. Data collection occurred over a 1-month period in December 2019. All data were directly entered electronically using UNICEF's Data4Action mobile application and exported into Microsoft Excel 2016 and Stata V.15.1 for analysis.

Patient and public involvement

Patients were not involved in the study. Interviews were limited to health workers.

Table 2 Sample health facilities and vaccine stores by region

		Central and south		North/KRI		Retaken areas	
Immunisation programme level	Facility type	Sampled facilities	Total facilities	Sampled facilities	Total facilities	Sampled facilities	Total facilities
Facility	PHC centres	48	696	12	253	14	220
	PHC subcentres	16	353	3	73	4	124
District	District Cold Store	12	49	4	35	3	16
	District Administration	7	34	1	13	2	7
DOH	DOH Cold Stores	10	14	2	3	3	4
Vaccine Doses (2018)*		923 202	10 716 304	787 589	2 043 047	200 864	2 577 286

*Doses estimated using district live births multiplied by district vaccination coverage provided by the Ministry of Health. The Ministry of Health estimated 1 117 512 live births in 2018 (Central & South: 744,792; North/Kurdistan Region of Iraq: 158,280; Retaken Areas: 214 440).
DOH, Directorate of Health; KRI, Kurdistan Region of Iraq; PHC, Primary Healthcare Center.

Calculation of vaccine delivery costs

The cost of immunisation programme activities at each facility or store were estimated using a bottom-up approach, in which the total amount of resources used was multiplied by the unit price, when possible. Capital costs were annualised using a 3% discount rate and the expected useable lifetime of the resource. Allocation of resources shared between the immunisation programme and other health services was estimated using tracing factors described in online supplemental appendix. For the estimation of costs by item, the time and resources spent on vaccine collection, outreach activities, supervision and routine immunisation meetings were disaggregated by personnel salaries and per diems, vehicles, cold chain, and so on. Data on the cost of community mobilisation activities at health facility levels and training costs at the national level were collected in aggregate. Due to missing data on shared resources and wide variations across facilities, we assumed the cost of printing and office supplies was negligible at the facility level and the central level, and the cost of printing immunisation materials was included at the DOH level. Detailed formulas and assumptions used to estimate each item and activity are described in the online supplemental appendix. The time horizon covered the 2018 calendar year. All costs were collected in Iraqi Dinar (IQD) and converted to 2020 USD using the World Bank Consumer Price Index estimates for 2018 (119.9) and 2020 (120.3). The 2020 exchange rate was 1189.24 IQD per 1 USD.[15].

Estimation of total immunisation services costs per FVC

The total cost of immunisation services was estimated nationwide and for each region by summing the weighted total and costs per dose at each level (facility, district, DOH and national). To account for the underlying relationship between costs and volume (ie, doses delivered), we extrapolated the costs to health facilities beyond the sample using calibration estimation following methods described by Rivera-Rodriguez *et al* in 2018 and 2019.[16 17] As explained in guidelines by Resch *et al*, this approach only requires information on the total volume of doses delivered nationally and the total number of health facilities.[18] Records on the number of doses delivered were inconsistently maintained at sampled facilities and unavailable for non-sampled facilities.

The sample weights, which were estimated following standard guidelines for multistage sampling of facility surveys,[19] were adjusted or calibrated based on the total number of facilities in each region and total doses delivered. The calibration incorporated the region and facility type (PHC centre vs subcentre; district store vs district administration) to improve precision. The volume of doses delivered in each district, directorate and region were estimated based on the district level target population multiplied by district vaccine coverage provided by the Ministry of Health (table 2). Cost per dose at each level was estimated by dividing weighted total cost by weighted total number of doses delivered. Because the extrapolation method accounts for the sample design and total volume of doses delivered, the unit cost for each level represents the national average. The cost per FVC using the Iraq schedule was estimated by summing the vaccine and injection equipment costs with the vaccine delivery costs. The cost per dose for each vaccine included the procurement price of the vaccine, price of injection supplies and safety boxes, the cost of handling and freight, and wastage. The 2020 immunisation schedule and vaccine prices are seen in table 3.

RESULTS

Total cost of vaccine delivery

The total cost to deliver an estimated 15.3 million doses in 2018, excluding the cost of vaccines and injection equipment, was US$99.35 million, of which 96% was for recurrent costs. The cost at the facility level was US$87.37 million (88% of total) followed by 8% at the district level, 2% at

Table 3 Childhood vaccination schedule in Iraq (2020)

Vaccine	Doses	Recommended age (months)	Price per dose (US$ 2020)	Vaccine wastage (%)
BCG	1	0	0.19	50%
Hepatitis B	1	0	0.55	25%
OPV bivalent 1+3	6	0, 2, 4, 6, 18, 4–6 years	0.22	25%
DTP-HepB-Hib	3	2, 4, 6	0.69	13%
PCV13	3	2, 4, 6	18.77	5%
IPV	2	4, 6	2.95	13%
Rotavirus	2	2, 4	6.65	5%
Measles	1	9	0.70	40%
Measles-Mumps-Rubella	2	15, 4–6 years	3.18	40%
DTwP	2	18, 4–6 years	0.17	20%

DTP, diphtheria-tetanus-pertussis; DTwP, diphtheria-tetanus-whole cell pertussis; IPV, inactivated polio vaccine; OPV, oral polio vaccine.

Table 4 Vaccine delivery cost by activity at each level (US$)

Activity	Facility level	District level	DOH level	Central level	All levels (%)	Per cent of total
Facility-based delivery	18 991 018	0	0	0	18 991 018	19.1%
Record-keeping and M&E	18 776 203	1 691 881	357 113	48 571	20 873 768	21.0%
Supervision	6 627 940	1 843 145	255 590	127 489	8 854 165	8.9%
Outreach delivery	9 414 830	2432	17 781	0	9 435 043	9.5%
Training	7 468 295	1 017 294	165 305	855 260	9 506 153	9.6%
Community mobilisation	121 403	0	0	0	121 403	0.1%
Vaccine transport	11 143 393	902 604	389 584	680 851	13 116 431	13.2%
Programme management	9 134 742	1 935 319	596 885	149 489	11 816 435	11.9%
Cold chain energy and maintenance	5 691 479	535 447	301 277	103 810	6 632 013	6.7%
Total	**87 369 304**	**7 928 121**	**2 083 534**	**1 965 469**	**99 346 429**	**100%**

DOH, directorate of health.

the DOH level, and 2% at the national level. Personnel salaries accounted for 89% of the total cost, and no other line item accounted for more than 3%. When assessing costs by activity, vaccine record-keeping and management accounted for 21% of the total, followed by routine facility-based service delivery (19%), vaccine collection, distribution, and storage (13.2%), project management (12%), and outreach service delivery (10%) (table 4). All other activities contributed less than 10% of the total. The high cost of record keeping was due to the considerable amount of time spent on spend on this, ranging from 25% to 28% of personnel time. Community mobilisation activities were limited to the facility level and contributed only 0.1% of total delivery cost. Outreach costs at district and DOH levels were all staff costs, primarily for supervision.

At the facility level, the cost of vaccine delivery was driven by facility-based vaccine administration (22%) and record keeping (22%). At the district level, the cost was driven by programme management (24%), supervision (23%) and record keeping (21%). Programme management was the main driver at the DOH level (29%). At the central level, 43% of costs were for training and 35% for vaccine collection and storage.

The overall cost of vaccine delivery was driven by the Central and South region, which is the most populous and has the most health facilities (1049 of 1719 total health facilities), accounting for 63% of the total cost (table 5), followed by the Retaken Areas (24%) and the North/KRI (13%). The distribution of costs across different activities varied by region (figure 1). Routine facility-based delivery and record keeping comprised the largest proportion of total cost in the Central and South and North/KRI regions. In the Retaken Areas, the cost of programme management was the main driver of cost, accounting for 37%. This was due to lower costs of other activities and not an increased cost of programme management activities. Excluding the cost of programme management, the distribution of other activities in the Retaken Areas was

Table 5 Cost per dose and total cost of vaccine delivery by region (US$)

	Central and south	North/KRI	Retaken areas	Nationwide
Cost per dose				
Facility level	5.23	5.38	7.88	5.70
District level	0.38	0.75	0.91	0.52
DOH level	0.10	0.21	0.21	0.14
Central level	0.13	0.13	0.13	0.13
Total	**5.84**	**6.47**	**9.13**	**6.48**
Total cost				
Facility level	56 059 646	10 994 484	20 315 174	87 369 304
District level	4 061 030	1 522 752	2 344 339	7 928 121
DOH level	1 123 216	430 190	530 128	2 083 534
Central level	1 373 350	261 827	330 293	1 965 469
Total	62 612 495	13 208 519	23 519 844	99 346 429
Per cent of total	**63%**	**13%**	**24%**	**100%**

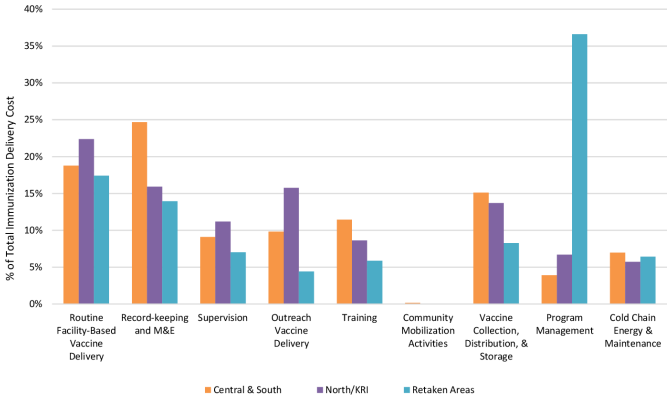

Figure 1 Distribution of activity costs according to region.

like the other regions. The combined cost of vehicles and maintenance was US$1.6 million, representing less than 2% of the overall cost. Many health facilities did not have facility-owned vehicles and instead relied on employees' personal cars, taxis, public transportation or walking.

Cost per dose delivered and costs per FVC

The average cost of vaccine delivery per dose (excluding vaccine and supply costs) was US$6.48, of which 88% was at the facility level (table 5). When stratifying by facility type, the average cost per dose delivered at the facility level was US$7.77 (SE: 1.85) and US$2.68 (SE: 2.25) at PHC centres and subcentres, respectively (table 6). The cost per dose for all levels in the Retaken Areas totaled US$9.13, followed by the North/KRI at US$6.47 and Central & South at US$5.84, respectively. The number of doses delivered in Retaken Areas was four times less than in the Central & South. Nationally, the vaccine delivery cost of fully vaccinating a child was US$149. When including vaccines and injection equipment, costs per FVC amounted to US$249 (table 7).

Of the 72 sampled PHC centres and 23 subcentres, 45 (63%) centres and 13 (57%) subcentres reported conducting outreach activities. The average number of outreach visits per month was 3.2 (SD 2.4) and 2.9 (SD 2.0) for centres and subcentres, respectively. Data on the number of doses delivered during outreach versus in facilities were not available.

Table 7 Cost per fully vaccinated child (FVC) for vaccines in Iraq's childhood immunisation schedule

Vaccine	Dose per FVC	Cost per dose (US$)	Cost per FVC (US$)
Vaccines and injection supplies			
BCG	1	0.48	0.48
Hep B	1	0.82	0.82
OPV	6	0.29	1.74
DTP-HepB-Hib	3	0.94	2.83
IPV	2	3.64	7.27
PCV13	3	19.80	59.39
Rotavirus	2	6.98	13.97
Measles	1	1.25	1.27
MMR	2	5.42	10.84
DTwP	2	0.35	0.66
Total vaccines and injection supplies	*23*		*99*
Vaccine delivery			
National level		0.13	2.99
DOH level		0.14	3.22
District level		0.52	11.96
Facility level		5.70	131.10
Total delivery costs per FVC			*149.27*
Total costs per FVC			**248.54**

DOH, directorate of health; DTP, diphtheria-tetanus-pertussis; Hep B, hepatitis B; MMR, measles-mumps-rubella; OPV, oral polio vaccine; PCV13, pneumococcal conjugate vaccine.

DISCUSSION

The total cost of immunisation services from the government perspective was US$99.35 million in 2018 when excluding the cost of vaccines and injection equipment. The estimated cost per dose delivered was US$6.48

Table 6 Weighted mean delivery cost by facility type among the sampled facilities

	Central & south	North/KRI	Retaken areas	Nationwide
PHC centres				
Sample size	48	12	14	74
Mean total cost (*95% CI*)	64 285 (56 825 to 71 746)	36 167 (18 758 to 53 576)	74 241 (47 159 to 101 324)	60 073 (52 682 to 67 464)
Mean cost per dose (*95% CI*)	8.15 (2.76 to 13.55)	6.31 (–18.47 to 31. 09)	7.74 (3.23 to 12.25)	7.77 (4.36 to 11.17)
PHC Subcentres				
Sample size	16	3	4	23
Mean total cost (*95% CI*)	28 448 (17 768 to 39 128)	22 991 (5534 to 40 448)	32 078 (21 593 to 42 562)	28 542 (21 151 to 35 933)
Mean cost per dose (*95% CI*)	2.09 (–1.20 to 5.39)	3.17 (–40.14 to 46. 472)	8.53 (–1.63 to 12.25)	2.68 (–1.17 to 6.53)

nationally. Average costs per dose were higher at PHC centres (US$7.77) compared with subcentres (US$2.68) due to higher total, annual costs at PHC centres explained by more qualified staff, more equipment and overheads. US$6.48 was higher than the cost estimated in a 2012 study conducted at five health clinics in Mosul (US$1.67 per dose).[20] However, the 2012 study only included the cost of personnel time administering vaccines at health centres and did not include costs at other levels of the health system.

Compared with other countries, the vaccine delivery cost per dose in Iraq was higher than modelled estimates for low-income and middle-income countries (US$1.87 per dose; uncertainty range US$0.64–4.38).[21] However, it is within the range found in a systematic review of vaccine delivery costs that showed an average of US$3.79 per dose, and a range from US$0.75 per dose in Benin to US$9.45 per dose in Moldova.[22] Of the countries included in the systematic review, the delivery cost per dose in Iraq was most similar to the cost per dose in Honduras (US$5.97), which was the proxy used in the sampling strategy.[13 22] Regionally, the unit cost per dose delivered was the highest in the Retaken Areas where years of conflict followed by recovery have required increased personnel, supervision and programme management compared with the other regions.

Overall, personnel were the main driver of the cost, accounting for 89% of total delivery cost. The percentage spent on salaries was higher than in other countries where salaries ranged between 30% and 60% of total delivery cost.[14] This was largely due to the relatively high cost of personnel benefits given in addition to the base salary. In many cases, the benefits were equal to the salary rate. At the facility level, facility-based delivery (22%) and record-keeping (22%) activities were the main drivers of cost. Compared with other countries, the proportion of the total cost spent on service delivery, including facility-based and outreach service, was less than other countries (32% in Iraq vs 53%–78% in EPIC countries) while the cost of programme management was higher (22% in Iraq vs 6–12% in EPIC countries).[14] Conversely, the annualised capital cost of vehicles was smaller than compared with other countries, and less than 1% of the total cost was spent on community mobilisation activities. Most facilities did not conduct community activities in 2018. When exploring differences by region, routine facility-based delivery and record keeping accounted for the highest percentage of cost in all regions except in Retaken Areas where the cost of programme management was 37% of the total cost.

The results of our analysis support findings from a 2019 review of the EPI vaccine supply chain system conducted as part of an Effective Vaccine Management Assessment (EVM).[9] The review revealed that even though there were improvements in maintaining the vaccine stock, shortages of some vaccines resulted in rumours in the community, which, combined with a lack of community mobilisation activities, decreased vaccine demand.[9] Although vaccine stock-outs were sometimes short-lived, there was no mechanism to inform parents that the vaccines had arrived. As a result, rumours continued in the community and led to less confidence in PHC services and reluctance to return. The decrease in demand led to vaccination coverage rates of less than 60% for PCV13 and rotavirus vaccines compared with 85% for DTP. The EVM assessment and coverage data indicate that additional focus on improving demand within the community is essential.

It is important to note that the delivery costs represent current practice and not how much it would cost to increase vaccination coverage or improve quality of services. With regard to quality, a 2018 assessment concluded that the vaccine supply chain in Iraq is adequately equipped with appropriate standard equipment as 97% of refrigerators, 80% of freezers, 67% of cold-boxes and 70% of vaccine carriers are WHO prequalified cold chain equipment.[23] Data on other types of quality measures, such as staff attitudes, waiting times and accessibility, would be important information to gather.

This study has limitations. First, we only included PHC centres and subcentres. While these are the main sites conducting routine immunisation, BCG vaccine given at birth are delivered in hospitals, and other vaccines may be delivered at small health houses as part of outreach services. Although we did not visit health houses for this study, we included outreach costs from the sampled facilities. However, since the number of doses delivered during outreach vs in facilities were not available, we could not compare the costs of delivery strategies; prospective data collection would be needed for such analysis. Second, we did not include the cost of surveillance activities and campaigns. In Iraq, the EPI surveillance system has over 1600 sentinel sites, of which 90% provide weekly updates. The early warning system for disease surveillance helps mitigate the irregularities in vaccination coverage rates and rapidly detect early warnings of disease outbreaks through weekly reports.[24] These surveillance activities are key to the success of the immunisation programme, but estimating their cost would be a separate study.

A third limitation was that the data availability and data quality varied between facilities. Some facility administrators interviewed did not have all the information requested, and the heterogeneity of health facilities in Iraq resulted in wide variability of activities conducted and resources used. For example, data on personnel salaries and equipment used for routine immunisation was well documented, but shared resources, including printing, office supplies and utilities was limited. Frequently, information on these shared resources was missing, and when they were available, the costs varied widely. This made it difficult to extrapolate across facilities, and assumptions were required to calculate costs. Similarly, universal assumptions were used to estimate the costs of cold chain operational costs because details on electricity expenditures and maintenance costs were not available from the facilities. Cold chain costs could vary between facilities in line with regional differences in temperatures; the

Southern region normally reach a high of 55°C during July/August compared with a maximum of 48° in the Northern region. Lastly, while 7 of the 141 sampled facilities reported using volunteer labour, data on the number of volunteers and time spent were not available from these facilities. Volunteer time may be less prevalent in Iraq than that in other places, but its exclusion from our analysis is a limitation.

A key question often asked by the MOH is what the costs of reaching unvaccinated children would be. This question cannot be fully answered by the present study because additional efforts, which can be costly, are needed to advance community outreach. Nevertheless, the results of this study can be used as part of future analyses to estimate the cost of increasing vaccine coverage.

Recommendations

This study provides a baseline understanding of the current programme costs and human resource uses that coupled with other EPI data can be used to assess programme performance, identify areas for improvement, and assess cost effectiveness of different system strengthening strategies. Streamlining record keeping, which is one of the main drivers of cost, especially in Retaken Areas, can improve efficiency by allowing personnel to spend time on other activities. The data generated from the facility assessment can be used to evaluate productivity indicators to quantify the routine immunisation programme efficiency at different levels and facilities.

Less than 1% of the total routine immunisation programme costs were for community mobilisation activities. As concluded by the 2019 EVM assessment,[9] increasing the investment in community mobilisation has the potential to improve the immunisation programme efficiency, decrease unnecessary visits to the health facility by caregivers, and increase vaccine coverage rates.

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