

BMJ Open Characterising the costs of the Global Polio Laboratory Network: a survey-based analysis

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To cite: Duintjer Tebbens RJ, Diop OM, Pallansch MA, *et al.* Characterising the costs of the Global Polio Laboratory Network: a survey-based analysis. *BMJ Open* 2019;**9**:e023290. doi:10.1136/bmjopen-2018-023290

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2018-023290>).

Received 4 April 2018

Revised 10 September 2018

Accepted 19 November 2018



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ABSTRACT

Objective To characterise the costs, including for environmental surveillance (ES), of the Global Polio Laboratory Network (GPLN) that provides laboratory support to the Global Polio Eradication Initiative (GPEI).

Design and participants We conducted a survey of the network across 92 countries of the 146 GPLN laboratories plus three non-GPLN laboratories that concentrate environmental samples to collect information about their activities, characteristics and costs during 2016. We estimate the total costs using regression of reported responses and complementing the findings with GPEI data.

Results We received responses from 132 (89%) of the 149 laboratories, with variable response rates for individual questions. We estimate that processing samples of patients with acute flaccid paralysis leads to total costs of approximately \$28 million per year (2016 US\$) based on extrapolation from reported costs of \$16 million, of which 61% were supported by internal (national) funds. Fifty-nine (45%) of the 132 responding laboratories reported supporting ES and we estimate an additional \$5.3 million of recurring costs for ES activities performed by the laboratories. The reported costs do not include an estimated additional \$10 million of annual global and regional costs to coordinate and support the GPLN. On average, the staff supported by funding for polio in the responding laboratories spent 30% of their time on non-polio activities. We estimate total costs for laboratory support of approximately \$43 million (note that this estimate does not include any field or other non-laboratory costs of polio surveillance).

Conclusions Although countries contribute significantly to the GPLN financing, many laboratories currently depend on GPEI funds, and these laboratories also support the laboratory component of surveillance activities for other diseases. Sustaining critical global surveillance for polioviruses and transitioning support for other disease programmes will require continued significant funding after polio certification.

BACKGROUND

Launched in response to the 1988 World Health Assembly resolution to globally eradicate all paralytic poliomyelitis caused by polioviruses, the Global Polio Eradication Initiative (GPEI) seeks to stop all polio.¹ By mid-2018, the GPEI succeeded in limiting

Strengths and limitations of this study

- High overall response rate from laboratories allows for estimation of costs across geographies, income levels and laboratory types.
- Results depend on self-reported cost estimates with possible differences in interpretation of the questions and availability of cost information.
- Analysis relied on extrapolation from relatively sparse data to estimate missing values, which may have introduced biases.

indigenous transmission of wild polioviruses to three countries (Afghanistan, Nigeria and Pakistan) by focusing on four key strategies: strengthening routine polio immunisation, supplemental immunisation activities, surveillance and outbreak response.² Four of the six WHO regions have been certified polio free and of the three wild poliovirus serotypes, serotypes 2 and 3 have not been detected since 1999 and 2012, respectively.^{3 4} High-quality surveillance represents a key contributor to these successes because it allows the GPEI to (1) monitor eradication progress, (2) determine where poliovirus transmission still occurs, (3) rapidly respond to any outbreaks in previously polio-free areas, and (4) achieve high confidence about the absence of transmission after the last detected poliovirus in any given area.

As part of the global strategy to manage the risks associated with the oral poliovirus vaccine (OPV),^{5 6} and following the certification of serotype 2 wild poliovirus eradication in 2015,⁷ cessation of attenuated serotype 2-containing OPV occurred in April to May 2016. The virologic monitoring of the disappearance of serotype 2 vaccine-related viruses from acute flaccid paralysis (AFP) cases and the environment represented an integral activity of the vaccine switch.⁸ Even after the eradication of the last circulating wild polioviruses, surveillance will remain critical to

manage future poliovirus risks. First, certification of wild poliovirus eradication and subsequent OPV cessation cannot safely occur without high confidence about the absence of transmission. Second, the risk of outbreaks continues to exist after OPV cessation,⁶⁻⁹ as already demonstrated by circulating vaccine-derived poliovirus outbreaks after serotype 2 OPV cessation,¹⁰ virus releases from polio vaccine manufacturing facilities,¹¹ and the existence of long-term excretors of immunodeficiency-associated vaccine-derived polioviruses.^{12,13}

Established in 1990, the Global Polio Laboratory Network (GPLN) supports poliovirus surveillance activities in countries by testing stool samples from patients with AFP (and sometimes their contacts) for the presence of polioviruses.¹⁴ AFP may indicate a poliovirus infection, but also occurs at a relatively predictable rate due to other causes (eg, Guillain-Barre syndrome), making the rate of non-polio AFP cases detected a good indicator of the ability of the surveillance system to detect AFP caused by poliovirus infection in a population.¹⁵ Currently the GPLN analyses over 200 000 stool samples per year from AFP cases and their contacts. In addition to AFP surveillance, which exists in all countries except for 20 high-income countries, some GPLN laboratories support supplemental surveillance through testing of environmental surveillance (ES) samples (eg, sewage), or stool collected from non-paralytic individuals (eg, healthy children surveys or patients with central nervous system diseases such as aseptic meningitis). Some laboratories also test for polio antibodies from sera (eg, from serological surveys). The GPLN currently consists of 146 laboratories across 92 countries with different roles (ie, subnational, national, regional reference and global specialised laboratories) and capacities (ie, sewage concentration, virus isolation, intratypic differentiation (ITD), sequencing and serology testing) that form a comprehensive international referral system to ensure testing of any specimen for the presence of poliovirus and sequencing of specific polioviruses (eg, suspected wild or vaccine-derived polioviruses).

The GPEI tracks its resource requirements for the GPLN, which estimated a budget of \$16.4 million for 2017 (compared with \$79 million for 'surveillance and running costs' in the field, and \$1.1 billion for all GPEI activities).¹⁴ However, no mechanism exists to systematically track the contributions by the countries hosting GPLN laboratories. A survey of GPLN laboratories conducted in 2003 found that external GPEI funds accounted for only 34% of the reported GPLN costs, with 47% coming from internal (ie, national) funds and 13% from bilateral cooperation funds not included in the GPEI budget.¹⁵ The analysis estimated total GPLN costs of \$21 million (2002 US\$, equal to \$28 million in 2016 US\$), including \$9 million for various coordinating and supporting activities by the GPEI and the global specialised laboratories. Since the 2003 survey, the number of countries dealing with polio outbreaks decreased significantly, the poliovirus detection and characterisation algorithms changed and the GPEI significantly increased its ES activities. Analysis of

ES samples involves a concentration step not needed for AFP samples, requires a separate workspace and impacts laboratory workloads and workflows.^{16,17} Given these changes and questions about the financial resources required to sustain poliovirus surveillance during the polio endgame, we conducted a survey following the same general approach as the 2003 survey¹⁵ to update the full laboratory cost estimates and better understand the extent and costs of poliovirus ES activities.

METHODS

Survey instrument

We developed an online survey instrument (see online supplementary appendix A1) modelled after the 2003 survey.¹⁵ With respect to costs, the instrument requests annual estimates for 11 major cost categories (see below) each for analysis of samples obtained through AFP surveillance and from ES. For the cost categories 'equipment' and 'durable supplies', we asked for annual amortised costs, defined as purchase, packing, freight and insurance costs divided by the expected useful lifetime, and we provided a spreadsheet to help respondents compute the annual amortised costs. In addition, for laboratories that recently (ie, between 2010 and 2016) established or significantly expanded their ES capacity, we requested estimates of the ES set-up costs for 10 largely overlapping cost categories relevant to establishing ES capacity. For all of these, we asked respondents to provide the breakdown of costs by funding source (ie, internal, external (GPEI), bilateral (non-GPEI, non-national)). The instrument further included questions about the role and capacities of the laboratories, geographical areas served, staff time spent on different activities, number of samples processed for different tests (eg, virus isolation, ITD, sequencing and, for ES samples, concentration), serological testing activities, non-polio surveillance activities supported by funding for polio (ie, polio-supported staff), the nature of ES activities and anticipated future changes in workload or workflow.

Process

We piloted the survey among all WHO regional coordinators of the GPLN and a small subset of laboratories before launching the revised, final instrument online and in PDF form in July 2017, in English, Chinese and Russian. We targeted all 145 active GPLN laboratories (we excluded one laboratory considered dormant) and three non-GPLN laboratories recently established to facilitate ES in countries with no easy access to a GPLN laboratory for sewage sample concentration and processing (ie, concentration-only laboratories). We followed up with responding laboratories to resolve any ambiguities or apparent inconsistencies in the responses (see online supplementary appendix A2 for a list of the responding laboratories). We reached out four times to non-responding laboratories to increase the response rate through November 2017 and closed the online survey instrument at the end of 2017.

Processing and analysis of results

We collected all original responses directly from the online survey instrument and manually entered any changes indicated by respondents during the follow-up. For rare instances in which a laboratory provided a range of costs for a category, we used the midpoint. Some respondents noted that they reported costs for consumable supplies or shared consumable supplies on a per-sample basis rather than as an annual total, which prompted us to systematically convert consumable supply costs to annual totals when we suspected responses per sample (see online supplementary appendix A3). We converted all monetary estimates to 2016 US\$ using publicly available exchange rates from 1 July 2016.¹⁸ We classified the income levels of laboratories based on the 2016 World Bank income levels of their host countries.¹⁹ Unless otherwise noted, all results represent the annual totals for 2016.

To account for missing cost responses from responding laboratories, we interpreted unanswered or zero responses differently depending on the cost category. We assumed that all laboratories incur costs under the six cost categories of personnel, equipment, durable supplies, consumable supplies, operations and shipping/transport (ie, non-zero categories). In contrast, we assume that some laboratories may truly not incur any costs for the five categories of training, shared consumable supplies, donated supplies, technical support and other (ie, possible zero categories). Furthermore, we preprocessed some of the cost data before further analysis because some respondents indicated challenges in separating costs between analysis of AFP and ES samples and others explicitly indicated that they reported only the combined costs. Compared with samples from patients with AFP, the processing of ES samples follows a more involved algorithm (ie, three times as many cell cultures),¹⁶ more often yields viruses that require ITD testing or sequencing (ie, because an ES sample represents a composite sample from many individuals) and requires about four times the processing time by trained staff.²⁰ The type and nature of adjustment depended on the nature of the missing data (see online supplementary appendix A3).

To account for non-responding laboratories, we considered variables that we could obtain outside of the survey for all laboratories from the web-based GPLN management system, including number of employee full-time equivalents (FTE) employed for poliovirus surveillance, and number of virus isolation tests, ITD tests and sequences performed on AFP samples. Based on differences between laboratories and descriptive analysis of relationships by WHO region, income level and laboratory role, we grouped the laboratories by income level and capacity (ie, virus isolation only, ITD and virus isolation but no sequencing, and sequencing (with or without ITD capacity)) for regression analyses. Within each group, we used univariate linear regression on the number of samples processed for virus isolation to estimate missing costs. In the event of negative intercepts

or slopes in a given cost category and group, we forced the intercept to 0, thus effectively reverting to estimation based on the simple average cost per sample processed for virus isolation for the given cost category and group. We also considered linear regression on the number of FTEs, multilinear regression on all variables and different grouping approaches, but found no substantial improvement or differences in the totals.

Other cost assumptions

To estimate the costs of analysis of serum samples, we assume costs of \$10 per sample for consumables and equipment. For the personnel costs, we multiply the reported average personnel costs per FTE in upper middle/high-income countries (since these countries test most of the reported serum samples) by the reported number of FTEs for processing of serum samples. We estimate the costs of research and development activities based on extrapolation of data from the largest global specialised laboratory (ie, the US Centers for Disease Control and Prevention (CDC) laboratory in Atlanta, GA) (MAP, MSO). We estimate the global overhead costs for coordination, training and technical support not incurred by individual laboratories based on WHO surveillance budgets (OMD).

Patient and public involvement

This survey did not involve patients or public opportunities for engagement.

RESULTS

Overall survey response and grouping

We received responses from 132 of 149 (89%) surveyed laboratories, which included one concentration-only laboratory. **Figure 1** provides the breakdown of the response rate by laboratory role, region and income level, which shows a response rate of at least 78% for all breakdowns, except for the three concentration-only laboratories, from which we received only one response (ie, response rate 33%). Based on the reported capacities, we grouped the 131 responding GPLN laboratories into 30 (23%) laboratories with virus isolation capacity only, 67 (50%) laboratories with virus isolation and ITD capacity and 35 (27%) laboratories with sequencing capacity (regardless of virus isolation and ITD capacity), with the concentration-only laboratory equipped with neither of those capacities. For the estimation of costs to process AFP samples, we further grouped the laboratories by income level into low/lower middle income versus upper middle/high income to allow more appropriate cost extrapolation while maintaining sufficient numbers of laboratories in each group. For the estimation of costs to process ES samples, we did not stratify by income level because of the smaller numbers of laboratories in this group.

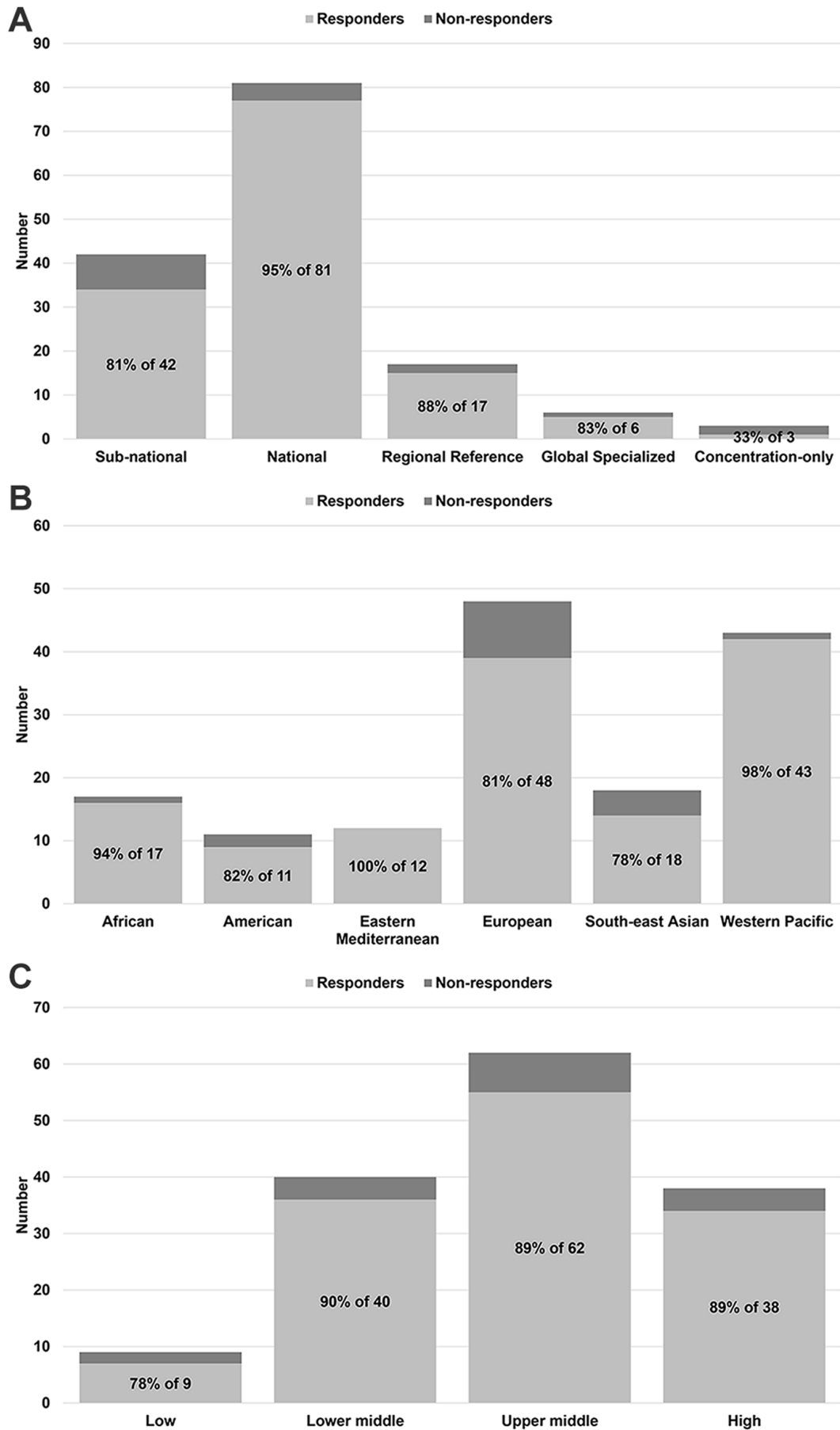


Figure 1 Survey response rates by (A) role, (B) region and (C) income level.

AFP sample processing costs

Table 1 summarises the breakdown in the laboratory types and the numbers of laboratories in each category. The reported costs to process samples from AFP cases and contacts for each individual cost category reflect different response rates for the various categories (table 1, numbers in parenthesis next to the reported costs show the per cent of laboratories reporting). The reported costs for each category remained markedly lower than the overall survey response rates (compare figure 1 with table 1), and show the highest reporting percentages for personnel and consumable supplies. The responding laboratories reported approximately \$16 million in total AFP-related costs (table 1), which does not include \$510 000 in reported AFP-related costs from 12 laboratories that we reallocated to processing of ES samples. Personnel accounted for 44% of all reported costs, followed by consumable supplies (21%) and equipment (20%).

Figure 2A shows the source of funding by cost category for the costs reported. Internal (national) funds accounted for a large proportion of personnel (76%), training (66%), equipment (64%), operations (79%) and technical support (85%) costs, while external (GPEI) funds accounted for a large proportion of costs for consumable supplies (72%), donated supplies (75%) and shared consumable supplies (54%). Overall, 61%, 36%, 2.4% and 1.3% of all reported funds to process AFP samples came from internal, external, bilateral and unspecified funds, respectively. Twenty-six per cent of laboratories reported dependence on non-internal funds for at least 50% of their budget, with regional percentages of 0%, 3.3%, 6.7%, 50%, 58% and 86% for the American, Western Pacific, European, Eastern Mediterranean, Southeast Asian and African WHO regions, respectively.

Finally, table 1 (bottom section) also reports the total costs estimated for each laboratory group and cost category, based on extrapolation to the entire network of laboratories. The resulting total AFP costs equal approximately \$28 million. Although the sequencing laboratories account for only 26% of the total number of GPLN laboratories, they account for 34% of the estimated lab-specific costs for processing of AFP samples.

ES sample processing costs

Fifty-nine (45%) of all 132 responding laboratories reported supporting ES activities, including one concentration-only laboratory. One additional laboratory that reported not analysing ES samples estimated the costs of supporting national ES activities with a staff member providing technical support. We excluded the latter laboratory and the concentration-only laboratory due to the absence of numbers of ES samples processed for virus isolation needed for inclusion in the regression. Seven non-responding GPLN laboratories support ES according to unpublished WHO data, leading to a total of 65 (45%) GPLN laboratories supporting ES activities in 2016.

Table 2 shows the reported and estimated recurring costs for ES based on the variable response rates for each cost category. The responding laboratories reported approximately \$3.2 million in total recurring ES-related costs, which includes \$510 000 in AFP costs that we attributed to ES. Varying the ratio of ES processing cost per sample to the AFP processing cost per sample from 3 to 10 changed the AFP processing costs attributed to ES processing from \$340 000 to \$590 000, respectively. Thus, the impact of this assumption on overall costs remains modest, because it only affects 12 laboratories with ambiguity about whether reported AFP processing costs included ES processing costs. The breakdown by cost category remained similar to the costs for processing of AFP samples, and similarly the sequencing laboratories accounted for a large portion (58%) of all reported recurring ES costs.

Figure 2B shows the breakdown by cost category and funding source for the reported costs in table 2, which shows a similar breakdown as for AFP sample processing costs. Overall, 65%, 22%, 0.3% and 12% of all reported recurring ES costs came from internal, external, bilateral and unspecified funds, respectively.

The bottom half of table 2 shows the extrapolated costs estimated in each group and for each cost category. The resulting total recurring ES costs equal approximately \$5.3 million. Table 2 does not factor in the relatively small costs from the one concentration-only laboratory that responded to the survey, which reported only some internally funded recurring ES costs for personnel with other costs captured in the ES set-up costs or unquantified because they paid for by external resources.

Of the 59 laboratories (ie, 58 GPLN laboratories and one concentration-only laboratory) that reported supporting ES activities, 35 (59%) reported that they recently (ie, between 2010 and 2016) set up or significantly expanded their ES capacity. Of these 35 laboratories, 25 (71%) provided set-up cost estimates for at least one cost category, leading to total reported set-up costs of approximately \$1.8 million. This includes estimates from 16 ITD laboratories, 6 sequencing laboratories, 2 virus isolation laboratories and 1 concentration-only laboratory. Only 6 of the 25 (24%) laboratories reported becoming fully operational during 2016, which suggests that most of the reported set-up costs did occur sometime between 2010 and 2015. Figure 3 shows the breakdown of the \$1.8 million of reported ES set-up costs, with the legend also showing the response rates for each set-up cost category. New equipment for concentration represented the largest contributor to all reported set-up cost (38%), followed by new equipment for expanded poliovirus processing capacity (12%), new personnel (12%), new consumable supplies (11%) and facility costs (10%). These results suggest that establishing new ES capacity in a laboratory costs approximately \$75 000.

Table 1 Reported and estimated costs to process acute flaccid paralysis samples, based on regression of reported total number of stool samples processed for virus isolation for the number of laboratories (n) in the category (excluding the costs for the concentration-only laboratories and global and regional costs for research and coordination)

Cost category	Laboratories with virus isolation capacity only (n=38)		Laboratories with ITD (and no sequencing) capacity (n=70)		Laboratories with sequencing capacity		All GPLN laboratories (n=146)
	Low/lower middle income (n=8)	Upper middle/high income (n=30)	Low/lower middle income (n=32)	Upper middle/high income (n=38)	Low/lower middle income (n=6)	Upper middle/high income (n=32)	
Total reported costs (% of all labs in group reporting non-zero costs)							
Personnel	1700 (25)	750000 (60)	2 100 000 (78)	1 100 000 (63)	490000 (67)	2 400 000 (78)	6 900 000 (67)
Training	2500 (13)	8900 (37)	37000 (25)	36000 (55)	250 (17)	51000 (41)	130000 (38)
Equipment	36000 (25)	190000 (60)	690000 (72)	1 000 000 (63)	3000 (17)	1 200 000 (69)	3 100 000 (62)
Durable supplies	2400 (25)	170000 (57)	120000 (59)	110000 (63)	9400 (33)	110000 (59)	530000 (57)
Consumable supplies	34000 (50)	190000 (60)	1 300 000 (59)	620000 (71)	900000 (50)	280000 (75)	3 300 000 (65)
Shared consumable supplies	2700 (38)	44000 (40)	84000 (41)	180000 (53)	290000 (33)	88000 (53)	690000 (46)
Donated supplies	4000 (13)	10000 (3)	5600 (6)	770 (3)	0 (0)	480 (9)	21000 (5)
Operations	4500 (25)	53000 (17)	170000 (53)	140000 (50)	53000 (33)	300000 (28)	730000 (37)
Shipping/transport	1200 (25)	24000 (30)	53000 (66)	32000 (61)	100 (17)	91000 (53)	200000 (50)
Technical support	200 (13)	14000 (23)	39000 (16)	43000 (26)	200 (17)	19000 (13)	120000 (19)
Other	0 (0)	7500 (3)	7400 (6)	1400 (3)	0 (0)	1600 (3)	18000 (3)
All cost categories	90000	1 500 000	4 600 000	3 300 000	1 800 000	4 500 000	16 000 000
Estimated total costs							
Personnel	9100	1 200 000	2 600 000	1 700 000	770000	2 700 000	9 000 000
Training	2900	9000	44000	39000	250	63000	160000
Equipment	4 200 000	290000	930000	1 200 000	18000	1 700 000	8 400 000
Durable supplies	270000	260000	200000	180000	33000	260000	1 200 000
Consumable supplies	150000	280000	1 400 000	810000	1 500 000	450000	4 600 000
Shared consumable supplies	8400	63000	87000	230000	290000	110000	790000
Donated supplies	4600	15000	6200	830	0	600	27000

Continued

Table 1 Continued

Cost category	Laboratories with virus isolation capacity only (n=38)		Laboratories with ITD (and no sequencing) capacity (n=70)		Laboratories with sequencing capacity (n=38)			All GPLN laboratories (n=146)
	Low/middle income (n=8)	Upper middle/high income (n=30)	Low/middle income (n=32)	Upper middle/high income (n=38)	Low/middle income (n=6)	Upper middle/high income (n=32)		
Operations	540000	550000	330000	250000	1 000 000	440000	3 100 000	
Shipping/transport	150000	40000	57000	55000	600	170000	470000	
Technical support	230	21000	40000	46000	200	20000	130000	
Other	0	11000	8200	1500	0	2200	23000	
All cost categories	5 300 000	2 800 000	5 700 000	4 500 000	3 600 000	6 000 000	28 000 000	

GPLN, Global Polio Laboratory Network; ITD, intratypic differentiation.

Other findings

We explored the breakdown of reported staff time spent on polio and non-polio diseases by WHO region for staff supported by funding for polio (see online supplementary appendix A4). We also characterised the reported number of samples or isolates processed in the context of different activities (see online supplementary appendix A4), with the approximately 250 000 samples from AFP cases and their contacts processed for virus isolation dominating the results and reflecting the primary focus of the GPLN on supporting AFP surveillance. Given the current prevalence of wild polioviruses and level of OPV use, roughly 4.5% of stool samples from AFP cases grow in the L20 B cells used for virus isolation. Of these, approximately 7% appear as possible wild or vaccine-derived poliovirus, which then undergo sequencing. In contrast, ES accounted for only 12 000 samples processed for virus isolation originating from 8200 environmental sample concentrates, 67% of which were concentrated using the WHO-recommended two-phase method.¹⁶ The difference between the number of concentrates and the number of isolates probably comes from laboratories that (re)tested samples already concentrated by another laboratory, including third-party laboratories not part of the GPLN.

Estimated overall GPLN costs

Table 3 estimates the full polio laboratory costs for 2016 based on the results of the survey complemented with data from the WHO and the CDC global specialised laboratory in Atlanta, GA. Using the results from tables 1 and 2, we estimate the total laboratory-specific costs to support AFP surveillance and ES at approximately \$33 million. This does not include the reported recent ES set-up costs of \$1.8 million, which represents only a fraction of the WHO-supported ES set-up costs for 2016, or the costs for the analysis of serum samples. For 2016, we estimate total costs of serology of approximately \$1 million, total costs of research and development activities of approximately \$3 million and global overhead costs for coordination, training, technical of approximately \$6 million. The resulting estimated total poliovirus laboratory costs for 2016 equal to \$43.3 million.

DISCUSSION

This study confirms the important contributions of both GPEI and internal funds to the maintenance of well-functioning poliovirus surveillance laboratories.¹⁵ For comparison, the 2003 survey estimated substantially lower total costs of \$28 million per year (ie, 21 million in year 2002 US\$). This estimate broke down as: (1) \$16 million of AFP-related costs for the (sub)national and regional reference laboratories; (2) \$8 million for all polio-related activities by global specialised laboratories, including limited ES conducted at the time; and (3) \$4 million in global coordination costs.¹⁵ In this study, the corresponding AFP-related costs for the (sub)national

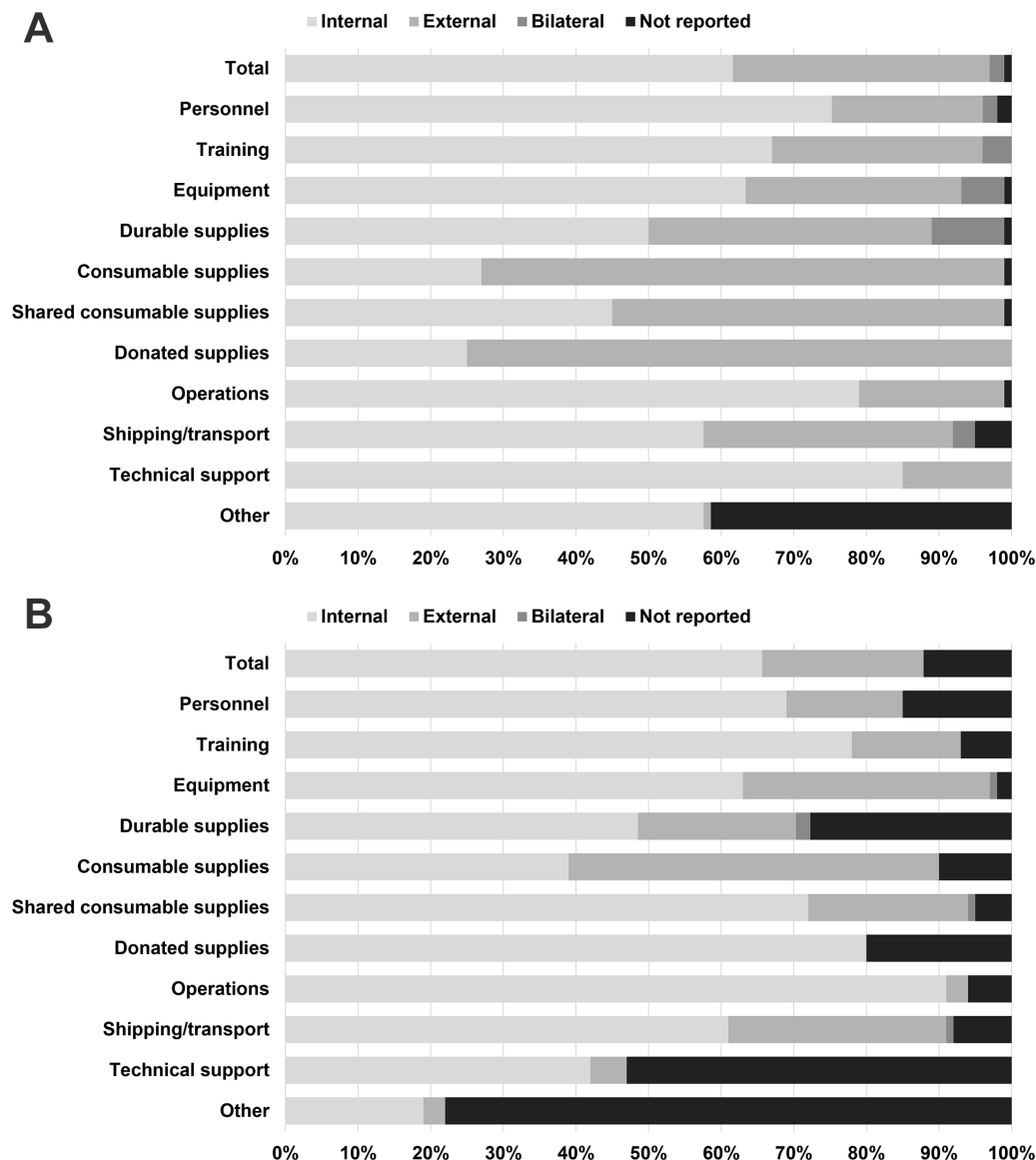


Figure 2 Reported costs by cost category and source of funding. (A) Costs to process acute flaccid paralysis samples. (B) Costs to process environmental samples.

and regional reference laboratories equal approximately \$25 million. The total estimated AFP and recurring ES costs for the global specialised laboratories equal only \$3.5 million, but increase to over \$7 million if we add the estimated research and development, serology, coordination, training and technical support costs.

While direct comparison of the absolute costs in 2016 to those in the 2003 study¹⁵ remains somewhat challenging due to differences in the specific cost requested, this study finds an apparent increase in the proportion of costs paid for by internal funds from 53% in 2003¹⁵ to 62% in 2016. This may reflect increasing self-funding of the laboratory component of polio surveillance activities by polio-free countries no longer at a high risk of outbreaks. In addition, after largely externally funded capital investments helped to set up laboratories with the capacity to apply molecular methods in many countries, the more often

internally funded personnel costs now represent a relatively larger share of the total costs.

The investments in capital costs may also have reduced the recurring costs compared with the 2003 survey, despite the increase from approximately 85 000 AFP samples tested in 2002 to almost 250 000 in 2016. Nevertheless, with 50% or more of GPLN laboratories in the African, Eastern Mediterranean and Southeast Asian WHO regions depending on external GPEI funds for at least half of their budgets for AFP sample analysis, planning for financing after the GPEI resources decline after certification remains of critical importance. In this context, we note that the GPEI budget for 2017 for the GPLN of \$16.4 million reflects only 17% of the GPEI budget for all surveillance activities (ie, costs associated with the field components of AFP surveillance dominate the costs in the GPLN budget for surveillance) and 1.5% of the overall GPEI budget for 2017.¹⁴

Table 2 Reported and estimated recurring costs to process environmental samples, based on regression by reported total number of environmental samples processed for virus isolation (results exclude costs from concentration-only laboratories)

Cost category	Laboratories with virus isolation capacity only (n=20)	Laboratories with ITD (and no sequencing) capacity (n=22)	Laboratories with sequencing capacity (n=23)	All GPLN laboratories doing ES (n=65)
Total reported costs (% of all labs in group reporting non-zero costs)				
Personnel	110 000 (40)	290 000 (77)	1 100 000 (70)	1 500 000 (63)
Training	7 400 (15)	17 000 (41)	42 000 (35)	66 000 (31)
Equipment	24 000 (35)	340 000 (73)	160 000 (52)	520 000 (54)
Durable supplies	22 000 (40)	42 000 (82)	20 000 (52)	84 000 (58)
Consumable supplies	51 000 (35)	210 000 (68)	120 000 (57)	380 000 (54)
Shared consumable supplies	5 600 (20)	18 000 (50)	80 000 (35)	100 000 (35)
Donated supplies	8 100 (5)	29 000 (9)	1 200 (4)	38 000 (6)
Operations	1 900 (5)	110 000 (73)	190 000 (35)	300 000 (38)
Shipping/transport	8 500 (25)	33 000 (77)	46 000 (43)	88 000 (49)
Technical support	1 600 (15)	6 300 (18)	51 000 (17)	59 000 (17)
Other	0 (0)	0 (0)	25 000 (9)	25 000 (3)
<i>All cost categories</i>	240 000	1 100 000	1 800 000	3 200 000
Estimated total costs				
Personnel	180 000	320 000	1 700 000	2 200 000
Training	15 000	17 000	61 000	94 000
Equipment	66 000	470 000	360 000	890 000
Durable supplies	47 000	52 000	42 000	140 000
Consumable supplies	120 000	310 000	340 000	760 000
Shared consumable supplies	12 000	18 000	130 000	160 000
Donated supplies	18 000	29 000	2 000	49 000
Operations	37 000	130 000	540 000	710 000
Shipping/transport	44 000	36 000	98 000	180 000
Technical support	2 100	6 300	73 000	81 000
Other	0	0	40 000	40 000
<i>All cost categories</i>	540 000	1 400 000	3 400 000	5 300 000

ES, environmental surveillance; GPLN, Global Polio Laboratory Network; ITD, intratypic differentiation.

This study further documents the significant contributions made by poliovirus laboratories to a large number of other disease surveillance efforts, with 30% of all polio-supported staff time reportedly used for surveillance of other diseases. Thus, we hope that this study highlights both the importance of contributions that countries make to poliovirus surveillance and the need to sustain funding to support laboratories worldwide in their surveillance efforts for poliovirus and other diseases. As global population immunity to poliovirus transmission decreases after OPV cessation,²¹ successfully controlling any future outbreaks will require continued vigilance and a rapid immunisation response.²² However, questions remain after the certification of eradication about the long-term financial sustainability of poliovirus surveillance and the functions of the GPLN, because of

the expected transition of key GPEI responsibilities and resources to other programmes.

Based on our results, the poliovirus laboratory costs to support ES remain relatively small compared with the AFP costs. This reflects the reality that despite the ongoing global ES expansion, ES remains limited to parts of some countries, while the global AFP surveillance system remains (nearly) universal. With the first phase of ES expansion continuing during 2017 and 2018, we expect both increased set-up costs during those years and higher recurring ES costs going forward compared with the ES costs estimated for 2016. With significant further expansion, the poliovirus laboratory costs for ES could exceed those for AFP, particularly if AFP surveillance declines, although we urge careful consideration of the costs and effectiveness of allowing AFP surveillance to decline.²³

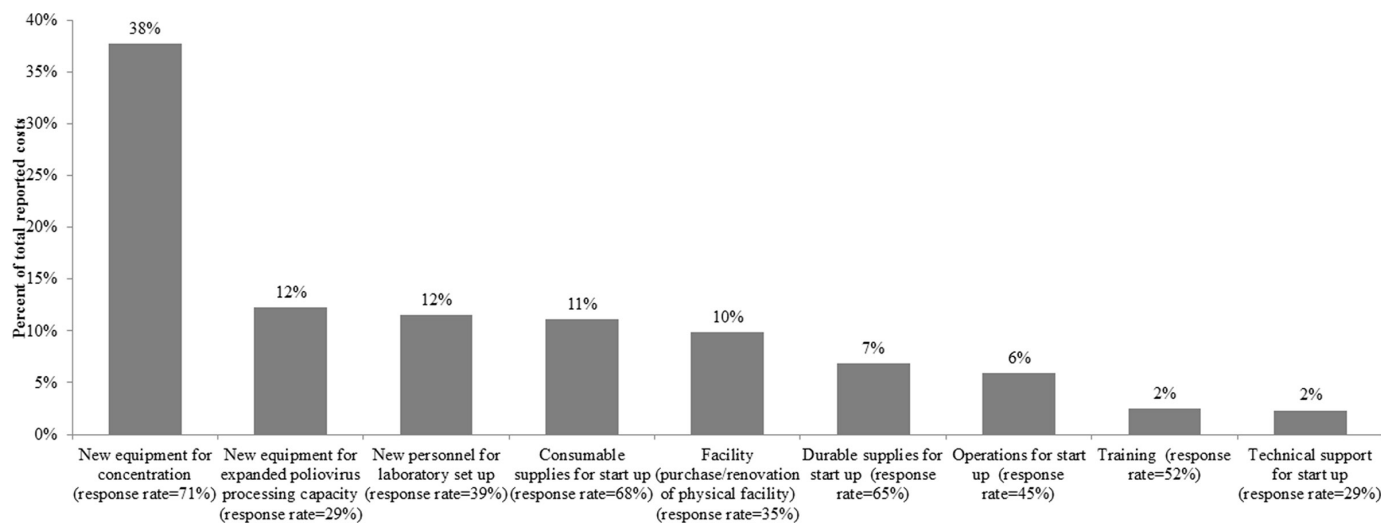


Figure 3 Breakdown by cost categories of reported environmental surveillance set-up costs. Response rates for each cost category represent percentages among 30 laboratories that reported having set-up or significantly expanded poliovirus environmental surveillance capacity between 2010 and 2016. The total reported set-up costs equal \$1.8 million.

This survey relied on self-reported estimates of laboratory costs. While we attempted to formulate the questions unambiguously and provided translations of the survey instrument and during follow-up where possible, we cannot rule out possible differences in interpretation of the questions. As described above, some respondents reported difficulties separating costs between categories and activities or amortising costs of equipment purchased long ago. Although we achieved a high overall response rate of 89%, the response rates for individual cost categories remained variable. Therefore, we relied on estimation based on regression of relatively sparse data to characterise missing values, which may have introduced biases. For example, laboratories receiving funding from the GPEI may be more likely to have omitted estimates for individual cost categories, potentially leading to relatively greater errors in the estimation of the external cost.

Table 3 Estimated overall poliovirus surveillance laboratory costs for 2016

Cost component	Amount (\$ millions)
Processing of samples from acute flaccid paralysis surveillance	
Reported	16
Estimated	28
Processing of samples from environmental surveillance	
Reported	3.2
Estimated	5.3
Serology	1.0
Research and development	3.0
Global and regional overhead (eg, coordination, training, technical support)	6.0
Total estimated annual laboratory costs	43

In addition, laboratories may not have accounted for all equipment, supplies and operations cost (eg, utilities, building maintenance) paid for by their hosting institutions, potentially leading to underestimation of the share of costs funded by internal sources. We also did not consider alternative data collection methods, which might have yielded different results (eg, instead of asking the entire population of laboratories to report annual estimates based on available data and recall we could have attempted to visit a sample of laboratories and observed activities and costs over some period of time and then extrapolated to the full year and full population).

Despite its limitations, we hope this study provides valuable insights regarding poliovirus laboratory costs and the cost structure of the GPLN. Future research to inform global long-term poliovirus and broader surveillance may include detailed cost studies of the field component of AFP surveillance and economic analyses of the value of AFP surveillance and ES.

CONCLUSIONS

Although countries contribute significantly to poliovirus laboratory finances, many laboratories currently depend on GPEI funds, and these laboratories also support the laboratory component of surveillance activities for other diseases. Sustaining critical global surveillance for polioviruses and other diseases will require continued funding as GPEI resources decline, particularly after global certification. Paying the costs to sustain surveillance represents an essential element for securing a polio-free world, and offers the opportunity to transition at least some of the current poliovirus laboratory resources to control/eliminate other vaccine-preventable or emerging/re-emerging communicable diseases.²⁴

Correction notice This article has been corrected since it published Online First. The PDF of the supplementary file was corrupt.

Acknowledgements The authors thank all GPLN and concentration-only laboratory personnel for providing valuable responses to the survey: Humayun Asghar, Cara Burns, Evgeniy Gavrilin, Varja Grabovac, Nicky Gumed-Moeletsi, Sirima Pattamadilok, Gloria Rey and Yan Zhang for helpful feedback on the survey instrument; Evgeniy Gavrilin and Zhu Shuangli for highly valuable help in translating the survey questionnaire into Russian and Chinese, respectively; and Patrick Briand, Stephen Cochi, Lee Hampton, Maria Iakovenko, Fem Paladin, Everardo Vega, Steven Wassilak and Marita Zimmermann for input at various stages of the process.

Contributors All authors (RJDT, OMD, MAP, MSO, KMT) contributed to the study design, survey instrument development, interpretation of data, manuscript writing and revisions. The first author (RJDT) performed the data analysis, the last author (KMT) coded and administered the survey instrument in SurveyMonkey, the second author (OMD) contacted the laboratories, and the first and second authors (RJDT, OMD) recruited participants and followed up with respondents on any questions.

Funding This publication was supported by cooperative agreement number 5NU2RGH001913-02-00 funded by the Centers for Disease Control and Prevention.

Disclaimer The contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The authors will provide the technical appendix provided to the reviewers.

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