Title: The actual and potential costs of meningitis surveillance in the African meningitis belt: results from Chad and Niger

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Word count:

Abstract: 298

Text: 4,175

1 **ABSTRACT**

2 **Background:** The introduction of serogroup A meningococcal conjugate vaccine in the African
3 meningitis belt required strengthened surveillance to assess long-term vaccine impact. The costs of
4 implementing this strengthening had not been assessed.

5

6 **Methodology:** The ingredients approach was used to retrospectively determine bacterial meningitis
7 surveillance costs in Chad and Niger in 2012. Resource use and unit cost data were collected through
8 interviews with staff at health facilities, laboratories, government offices and international partners, and
9 by reviewing financial reports. Sample costs were extrapolated to national level and costs of upgrading
10 to desired standards were estimated.

11

Results: Case-based surveillance had been implemented in all 12 surveyed hospitals and 29 of 33 surveyed clinics in Niger, compared to six out of 21 clinics surveyed in Chad. Lumbar punctures were performed in 100% of hospitals and clinics in Niger, compared to 52% of the clinics in Chad. The total costs of meningitis surveillance were US\$ 1,951,562 in Niger and US\$ 338,056 in Chad, with costs per capita of US\$ 0.12 and US\$ 0.03, respectively. Laboratory investigation was the largest cost component per surveillance functions, comprising 51% of the total costs in Niger and 40% in Chad. Personnel resources comprised the biggest expense type: 37% of total costs in Niger and 26% in Chad. The estimated annual, incremental costs of upgrading current systems to desired standards were US\$ 183,299 in Niger and US\$ 605,912 in Chad, which are 9% and 143% of present costs, respectively.

Conclusions: Niger's more robust meningitis surveillance system costs four times more per capita than the system in Chad. Since Chad spends less per capita, fewer activities are performed, which weakens detection and analysis of cases. Countries in the meningitis belt are diverse, and can use these results to assess local costs for adapting surveillance systems to monitor vaccine impact.

Keywords: Cost, meningitis, surveillance, Chad, Niger.

INTRODUCTION

The African meningitis belt, stretching from Senegal to Ethiopia, has the highest rates of meningitis in the world (see Figure 1 in Online Appendix for a map of countries in the African meningitis belt). The phased introduction since 2010 of MenAfriVac®, a new meningococcal conjugate vaccine, has reduced serogroup A meningococcal meningitis incidence¹ and provided indirect protection^{2 3}. High quality surveillance remains important to detect shifts in epidemiological patterns and for vaccine effectiveness estimates. Consequently, upgrading the existing enhanced surveillance (ENS) system to a more informative and systematic case-based surveillance (CBS) system is recommended⁴.

Both ENS and CBS work within the global strategy of the Integrated Disease Surveillance and Response Framework (IDSR)⁵, which has the objective of harmonizing and making more efficient disease surveillance in the African region. Specifically for meningitis, a major goal of ENS is

42 identification of epidemics for initiation of vaccination campaigns. Most countries in the African
43 meningitis belt have since early 2000 used ENS. ENS uses summary reports of basic information on
44 meningitis cases collected at district level, which are sent to national level without disaggregation by
45 individual patient. Some countries in the region have now moved to CBS, which aims to have a more
46 detailed case report form sent for each case. The CBS system includes performance of LP and
47 collection and analysis of cerebrospinal fluid (CSF) specimens for each suspected meningitis case
48 throughout the year. Lumbar puncture (LP) may be limited to a fraction of cases during an epidemic, or
49 to only outside of the epidemic season, with other cases counted based on clinical presentation. CBS
50 also links clinical and laboratory data with a unique case identification number, allowing for more
51 sophisticated analyses. CBS allows for assessment of risk groups (e.g., age, sex), evaluation of
52 vaccine failures (by collecting vaccination status), determination of incidence, including stratified by
53 etiology, and other evaluations.

54

55 However, the establishment of systematic CSF collection and analysis of all suspected meningitis
56 cases through CBS demands increased resource utilization⁴. Previous studies on surveillance costing
57 have shown that over the period 2002-2005 the cost to implement the IDSR framework in Eritrea,
58 Burkina Faso and Mali was on average US\$ 0.16, US\$ 0.04 and US\$ 0.02 per capita, respectively⁶.
59 However, no previous evaluations have quantified either the absolute costs of ENS or CBS in the
60 meningitis belt or the marginal costs beyond ENS. Because meningitis surveillance in the meningitis
61 belt has unique aspects, studies specific to this area are needed for informed decision-making.

62

63 The objectives of this study were to estimate the costs of existing meningitis surveillance in two
64 countries of the African meningitis belt, one using primarily ENS and limited CBS (Chad), and the
65 other primarily CBS (Niger), and to determine the incremental cost of upgrading these systems to
66 meet defined CBS operational standards. The two countries were selected partly because of already
67 established institutional links and also because between them several of the WHO recommended
68 surveillance strategies were represented in their national surveillance plans of action. The inclusion of
69 two countries with substantially different surveillance system designs and investments allowed us to
70 explore a range of cost implications faced by meningitis belt countries in moving towards robust CBS.
71 In addition, the study aimed to add to the existing limited literature on costing of disease surveillance,

72 particularly for meningitis^{7 8 9}. Study design considerations benefited from previous costing studies as
73 well as earlier studies on meningitis surveillance^{10 11}.

74

75 **METHODS**

76 The study estimated the costs of meningitis surveillance in 2012 in Niger and Chad from the
77 perspective of public health service delivery, whether financed from local or external sources. A micro-
78 costing approach, also called the ingredients or bottom up approach, was used, which entails
79 determining quantities of resources and their respective unit costs¹². Cost and process data were
80 collected retrospectively between September 2013 and February 2014. We included opportunity costs,
81 such as personnel time devoted to surveillance and infrastructure costs, which may not be included in
82 surveillance budgets. Cost data were denominated in local currency and converted into 2012 US\$ at a
83 rate of 1 US\$= 511 CFA¹³. As noted below, similar but not identical methodology was used in each
84 country, based on available data and differences in existing systems. This limited our ability to conduct
85 a strict comparison between the two countries. Nevertheless, we consider it important to present data
86 from each country to compare the costs of different types of systems within the meningitis belt.

87 **Sampling**

88 Purposive sampling was used to ensure inclusion of sites from different geographic areas with recent
89 meningitis cases. Data were collected using similar structured questionnaires in both countries.
90 Districts and facilities were classified according to urban/rural status (based on the possibility that
91 costs differed in urban centers compared to other areas) and ENS/CBS system. A major difference
92 between countries was that we included clinics and hospitals for Niger, but only clinics for Chad (Table
93 1). We use the term “clinics” to refer to primary health care centers and the broader term “health
94 facilities” to refer to both clinics and hospitals.

95 **Cost classifications**

96 Resources used in meningitis surveillance were classified into personnel (e.g. salaries), transportation
97 (e.g. vehicles), laboratory (e.g. microscopes) and office (e.g. buildings), and comprised recurrent and
98 capital costs (Table 1 Online Appendix). This classification was adapted from the SurvCost tool^{14 15}, a
99 spreadsheet-based tool developed in Excel to estimate the cost of resources involved in disease

surveillance. SurvCost organizes resources into seven categories and includes cost calculation formulas.

The classification of surveillance functions was built on existing frameworks^{16 17 18}. Surveillance functions were classified as core functions (detection, reporting, laboratory investigation, data analysis and follow-up) and support functions (training, supervision, information, education and communication, and coordination). We excluded the cost of responses that occurred based on surveillance data, as we did not consider this part of the core surveillance function.

Current cost calculations

The methodological differences between the studies of Niger and Chad are summarized in Table 2 of the Online Appendix. Although both countries followed the ingredients approach, country cost calculations differed in that Niger aggregated costs by resources used for surveillance^{19 20}, whereas Chad stratified costs by activity performed^{21 22 23}. Niger's costs were estimated as:

$$C_i = Q_i \times P_i \times \% \text{ all surv}_i \times \% \text{ mening surv}_i$$

The cost of the resource 'i' (personnel, transportation, laboratory and office resources - Table 1 of Online Appendix) was calculated by multiplying its quantity by price by the percentage of all activities devoted to overall surveillance (of all diseases), and by the percentage to meningitis surveillance out of overall surveillance. Apportions of resources for meningitis surveillance were obtained from personnel self-reporting for each resource at each site, where prices and quantities were also collected. Costs from the Niger national reference laboratory were estimated based on its 2012 budget. For Chad, self-reported data were captured by asking participants the mean amount of time (in minutes) they spent on each meningitis-related surveillance activity in 2012. This was done for each function to make it easier for participants to recall. Unit costs of resources in Chad were collected from budgets and accounts from the Chad MoH and partner agencies (e.g. CDC, MenAfriCar, Médecines sans Frontières and World Health Organization (WHO)), with data being cross-checked for accuracy with key country experts (e.g. procurement officers and laboratory experts).

Overhead costs were not obtained for Chad and only in some cases for Niger because of data limitations. When no cases were reported (33% and 60% of clinics in Chad and Niger, respectively), Niger accounted for any costs self-reported by facilities, whereas Chad included only data reporting,

data analysis and supervision costs. The annualization of capital costs followed the standard parameters of SurvCost⁶.

In Niger, average costs per capita by structure were derived from the sample and extrapolated to the total national costs taking into account rural and urban differences (78% of Niger's population being rural²⁴) and implementation of CBS nationwide. In Chad, there were three classifications of district surveillance strategy: exclusive ENS, partial CBS and exclusive CBS. Partial CBS referred to three districts (Gounou-gaya, Guelengdeng, and Ndjamena Nord) in which limited CBS was established and supported for four months as part of a meningitis research study²⁵, with ENS in place for the remainder of the year. Analyses for Niger used the highest number of suspected meningitis cases reported either at surveyed facilities or from the national reference laboratory. Analyses for Chad used the number of cases reported by laboratories for the current cost calculation and the cases reported in two high functioning districts, Moissala and Goundi, were used in the upgrading calculations.

Upgrading cost calculations

Desired operational standards were derived from an analysis of surveillance processes and based on meeting standard operational procedures (SOPs) as per the guide from the WHO for CBS for Bacterial Meningitis in the WHO African Region²⁶ plus adaptation to country contexts such as national plans²⁷²⁸. These standards were used to estimate the costs of upgrading the existing surveillance systems. The scale-up of costs was generated by estimating the costs of implementing the activities and resources involved in working towards the WHO standard. The activities identified were based on the performance study undertaken in each country, and the costs employed in the calculations were based on the current costs estimated.

RESULTS

Niger

Total and average costs per capita and per case were higher for Niger compared to Chad (Table 2).

In Niger, all 12 hospitals and 29 out of the 33 clinics (88%) in the study conducted CBS. All health facilities performed LPs, which were performed in all reported cases in all hospitals and in 80% of the

clinics surveyed. Niger's total and average costs differed substantially across administrative levels (Table 3). Health facilities accounted for 61% of total costs, followed by laboratories (32%) and MoH administration (7%). Rural and urban average costs per 100,000 population were US\$ 7,865 and 2,946 for clinics, respectively, and US\$ 248 and 1,684 for district hospitals, respectively.

In Niger, personnel resources contributed the most to the aggregated national cost (US\$ 720,600 or 37%), followed by laboratory resources (US\$ 374,816 or 19%). When disaggregating by administrative level, cost of personnel resources were also highest at the clinic level (US\$ 546,833 or 46%). However, the cost of laboratory resources was highest at the rest of administrative levels, that is at district (US\$ 94,966 or 36%), regional (US\$ 40,871 or 45%) and central (US\$ 240,320 or 49%) levels. Recurrent costs were greater than capital costs (76% to 24%). Table 3 in Online Appendix provides disaggregated details of total costs stratified by recurrent and capital costs, resource category, and health structure, and administrative level. Within surveillance functions (Figure 1), laboratory investigation accounted for most costs (US\$ 995,047 or 51%), and this was also the case at all administrative levels. Core functions accounted for US\$ 1,798,391 or 92% of total costs, while support functions contributed US\$ 146,571 or 8% (MoH central level excluded).

Cost per meningitis case varied across administrative levels, from US\$ 894 in clinics to US\$ 76 at the national hospital. However, of cases identified at clinics, up to 90% were not registered at the national reference laboratory. In addition, up to 78% of samples analyzed by the national reference laboratory were not registered by the health facilities surveyed. Furthermore, clinics with zero reported cases spent nearly the same as clinics with reported cases (average cost per 100,000 population of US\$ 4,051 vs. US\$ 4,600). Equally, a similar fraction of total work time was spent on meningitis surveillance by staff at clinics with and without cases (6% vs. 5%). The number of cases per clinic ranged between one and six suspected cases, with an average of 2.7.

In Niger, the estimated costs of upgrading the current system to operational standards would amount to US\$ 183,299, or 9% of the current cost (Figure 2). Laboratory investigation would consume US\$ 115,159 or 63% of the upgrading cost.

Chad

In Chad, one of seven districts in the sample (Moissala) performed CBS; three performed partial CBS, and the other three districts ENS. Only doctors were legally authorized to perform LPs, but none of the surveyed facilities employed a medical doctor. This resulted in uncertainty among the health staff about whether nurses could perform LP. Half of the facilities (47%) did not perform LPs, with 33% of them referring patients to the district hospitals for the procedure. Only 6% of suspected meningitis cases were analyzed by the laboratory and had a known outcome.

In Chad, laboratory analysis comprised 40% of total costs (Figure 3). This was distributed between analysis at district laboratories, the national laboratory in N'Djamena and at the reference laboratory in Oslo, Norway. As a consequence of not having real-time PCR capacity, during 2012 the national laboratory in Chad sent 85% of positive samples for confirmation to the WHO Collaborating Centre for Reference and Research on Meningococci in Oslo²⁹. Table 4 summarizes the unit costs of meningitis surveillance activities.

Mean costs per 100,000 population among districts performing exclusive ENS, partial CBS and exclusive CBS were US\$ 3,228, US\$ 3,593 and US\$ 7,449, respectively. The districts of Goundi (exclusive ENS) and Moissala had outbreaks of serogroup A meningococcal meningitis in 2012 and detected a considerable number of cases (Table 4 of Online Appendix). These and the exclusive ENS districts did not receive mass vaccination with MenAfriVac® until later in 2012. In contrast, the partial CBS districts received vaccination during 2011 and notified very low case numbers. The number of cases collected from district surveillance offices during the study differed from the numbers notified by the national surveillance system for all districts surveyed.

The estimated incremental costs per year of having a national CBS system that adhere to operational standards would amount to US\$ 605,017, equivalent to a 179% increase in current costs. With such an upgrading, total costs would be approximately US\$ 943,072 per year, equivalent to US\$ 7,449 per 100,000 population.

DISCUSSION

The findings depict two different surveillance levels, with Niger's cost four times that of Chad's: US\$ 0.12 versus US\$ 0.03 per capita. The higher costs reflect the nationwide implementation of the more intensive CBS in Niger compared with its limited introduction in Chad. Results from Niger show the significant economic effort and opportunity costs of maintaining CBS across all health facilities in the territory. In particular, clinics consume most of the national cost due to elevated mean costs linked to the lower number of population served and cases detected, plus the higher costs incurred by the more common rural clinics. These clinic-based surveillance costs occur even in the absence of cases since surveillance systems need to be in place regardless of case identification. The high contribution of recurrent (versus capital) costs highlights the need for ongoing and sustainable financing.

Chad's lower cost was linked to having less systematic detection and analysis of samples encountered. The less systematic sample analysis was partly due to the lower requirements as per ENS criteria. At the same time, there was a direct link between the robustness of surveillance system components (e.g. LP policy, training and logistics), and the number of cases detected. Chad would benefit from having a clear policy on the type of healthcare staff permitted to perform LP, and providing them with the necessary training and materials.

The wide cost difference between Chad and Niger emphasizes the importance of including data from different types of surveillance when estimating surveillance costs in the meningitis belt. Similar wide country variations were found in earlier estimations of the cost of surveillance for all diseases under the Integrated Disease Surveillance and Response (IDSR) systems, including US\$ 0.02 in Mali, US\$ 0.04 in Burkina Faso and US\$ 0.16 per capita in Eritrea annually between 2002-2005⁸.

Results from Niger and Chad pointed at laboratory investigation as the major cost driver among surveillance activities, contributing about half of current costs and an even greater percentage of upgrading expenses. The costs for national reference laboratories were higher than for other laboratories as these were responsible for performing more advanced tests, and also the distribution of rapid tests for meningitis detection to health facilities in Niger.

Niger had made significant investments in implementing CBS nationwide at the time of the study and consequently relatively little extra resources were needed beyond what was already spent. The opposite was the case for Chad, where larger investments would be required to improve surveillance. Chad has previously improved meningitis surveillance by implementing CBS in several districts as part of the MenAfrCar study³⁰. However, when external funding ended, substantially fewer CSF samples were taken and laboratories started to lack crucial supplies. The Chadian Government has subsequently prepared plan for implementing CBS in pilot districts, but implementation has been slow. Because Niger's CBS system performed better and cost more, the implications for other countries must be considered within local contexts of disease, activity prioritization and resource constraints.

Study limitations were substantial. Costs per case results should be taken with caution; it is prone to fluctuations due to seasonal changes of incidence; besides, large discrepancies between sources indicate that not all suspected cases were ultimately registered and suggest a large underreporting of cases. In addition, determining cost of surveillance of one disease is difficult due to shared costs employed under the IDSR scheme. Moreover, the comparison of results was hindered by methodological differences between countries. Niger's costs may have been overestimated due to reporting bias from respondents, which may have inflated the apportioning of staff time and costs to meningitis surveillance. Chad's average costs may have been under-estimated due to the omission of data from district hospitals (where most cases would likely be detected) and of overhead costs; additionally, we assumed that clinics with no reported cases incurred only reporting, analysis and supervision costs, while given the suspected under-reporting, it is possible that costs may have been incurred also on detection and laboratory investigation. In addition, upgrading methodologies were based on a gradual move towards the SOPs adapted to each country's context, which would underestimate the cost of a complete upgrade. Our purposive sampling prioritized districts with a substantial previous number of meningitis cases, thus potentially overestimating the resources employed and discrepancies between cases reported. Finally, the inclusion of two countries with different baseline surveillance system designs and costs likely increased study representativeness for other meningitis belt countries. Nevertheless, it is unlikely that other countries can apply reported costs for either Chad or Niger directly to their situation. Instead, countries could use the results we report as a guide and consider conducting their own assessment using our methodology.

278

279 **CONCLUSION**

280 Several lessons can be drawn from our results. Niger data underscore the high opportunity costs of
281 paying to implement CBS across all health centers throughout the geographic territory. At the other
282 end of the spectrum, data from Chad highlight the difficulties of conducting cost studies where there is
283 a risk that the health system and associated surveillance structures are too weak to identify and notify
284 meningitis cases.

285 The most appropriate system for other countries will depend on local contexts, such as competing
286 healthcare priorities and resource constraints. Additionally, the purpose of the surveillance system
287 must be considered. For example, if the goal is mainly to monitor for disease emergence due to new
288 serogroups, reinforcing surveillance in a few surveillance districts may be adequate. By contrast, if the
289 goal is to conduct comprehensive monitoring of system performance (e.g., vaccine failures, clinical
290 outcomes, emergence of antibiotic resistance) at all levels, national CBS would be more appropriate.
291 Mixed systems may also be applicable, for example having CBS at sentinel hospitals or selected
292 districts. Regardless, costs should be part of the decision-making process. Future studies might
293 include an explicit statement from national MoHs of the surveillance outcomes they want to achieve,
294 so that costs outcomes would address the most meaningful issues for local contexts.

295

296 **Conflict of interest and ethical considerations**

297 The study was funded by the Bill and Melinda Gates Foundation, which only contributed financially.
298 There are no conflicts of interest to be declared. The work has been carried out in an ethical way. All
299 authors have approved the final article.

300

301 **Authors' contribution**

302 All authors contributed to the research and reviewed and/or contributed to the manuscript.

303 MIL conducted cost calculations and analysis for Niger, wrote the Niger study report, first draft of the
304 manuscript.

305 NE contributed to protocol development, managed the Chad field research team, conducted data
306 collection and co-wrote the Chad study report.

307 AD supervised the field research in Niger.

308 UG contributed to protocol development, conducted cost calculation and analysis for Chad, co-wrote
309 the Chad study report, principal investigator for the Chad study.

310 JS contributed to protocol development, co-wrote the Chad report.

311 KF contributed to protocol development and provided inputs to country reports and final manuscript.

312 OL provided inputs to country reports and final manuscript.

313 AC contributed to protocol development, coordinated the study, and provided technical guidance as
314 principal investigator for the Niger study.

315 JBLG replaced AC in coordinating the study and principal investigator for the Niger study.

316 BDG contributed to protocol development, provided scientific direction and technical inputs to the
317 overall investigation and more in particular to the manuscript and Niger country report.

318

319 **Acknowledgements**

320 We are thankful to those who contributed to this study, in particular the Chad and Niger Ministries of

321 Health for allowing and facilitating the study. In addition, we would like to thank the research teams in

322 Chad and Niger, the research associates from AMP, and the staff from other organizations who

323 contributed to the investigation: WHO country and Geneva offices, and in Chad the Hôpital General de

324 Reference Nationale, Centre de Support en Santé Internationale, Centers for Disease Control and

325 Prevention, Carter Centre, and the MSF-France Chad country office.

326 We would also like to express our gratitude to the Bill & Melinda Gates Foundation for financing this project.

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Figure 1: Distribution of Niger’s total costs across meningitis surveillance functions, US\$, 2012.

Figure 2: Comparison of Niger’s current and upgrading cost of meningitis surveillance, US\$.

*IEC stands for information, education and communication

Figure 3: Distribution of Chad's total costs across meningitis surveillance functions*, US\$, 2012.

* No training or information, education and communication activities related to meningitis surveillance were registered in 2012. The study of Chad did not register coordination costs in the same year, and costs for data reporting and analysis are reported together.

Table 1: Study sample.

Study sample	Niger	Chad
Regions	7	4
Districts	10	7
Clinics	33*	21
District hospitals (all performing CBS)	8**	
Regional hospitals (all performing CBS)	2***	
National hospitals (all performing CBS)	2***	
District laboratories	8**	6
Regional hospital laboratories	2	1
National hospital laboratories	2	
National laboratory of reference	1	1
Surveillance offices from the MoH	22	13
Partner organizations	2	4

* Selected randomly representing 15% of the clinics within each district.

** Two districts did not have district hospital nor laboratory.

*** Part of the pediatric meningitis network

Table 2: Meningitis surveillance costs in Chad and Niger, 2012 (US\$).

	Chad	Niger
Total cost	338,056	1,951,562
Mean cost per capita	0.03	0.12
Mean cost per suspected meningitis case	87	6,215 ^a
Number of suspected meningitis cases	3,876 ^b	314 ^c
Population	12,661,091 ^d	16,274,738 ^e

^a Includes health facility, laboratory and administrative costs. This is believed to be an overestimation due to suspected underestimation of cases reported.

^b Gamougam K, Daugla DM, Toralta J, Ngadoua C, Fermon F, Page AL, Djingarey MH et al. Continuing effectiveness of serogroup A meningococcal conjugate vaccine, Chad, 2013. Emerg Infect Dis. 2015; 21 (1): 115-8.

^c Source: CERMES 2013. Résultats d'examens de LCR (bactériologie et/ou PCR). 25 April 2014. Unpublished. This is believed to be an underestimation of the real number of cases suspected based on discrepancies with research findings.

^d Source: Ministère de Santé Publique du Tchad. Stop Transmission of Polio (STOP) Tchad Team Final Report, June 2014, Service de Surveillance Epidémiologique Intégrée.

^e Source: République du Niger. 2013. Annuaire des statistiques sanitaires de Niger. Ministère de la Santé Publique, Secrétariat General, Direction des Statistiques. November 2013.

Table 3: Meningitis surveillance costs in Niger: sample and mean per 100,000 population in the sample, and total cost, per administrative levels and health structures, 2012 (US\$).

Level	Sample cost	Mean cost per 100,000 population ^{a b}	Niger total cost ^c
Primary health care level	56,556	5,778 (5,119)	1,106,346 (57%)
Clinic	56 556	5,778	1,106,346
District level	80,529	2,013	264,812 (14%)
Hospital	12,413	427 (546)	63,314
Laboratory district hospital	40,830	1,010 (2,477)	105,337
Surveillance administration	27,286	576 (514)	96,160
Regional level	51,452	749	91,726 (5%)
Hospital	2,894	52 (13)	5,545
Laboratory regional hospital	25,964	444 (444)	47,144
Surveillance administration regional hospital	2,098	36 (22)	3,822
Surveillance administration	20,495	216 (277)	35,216
Central level	488,678	3,003	488,678 (25%)
National hospital	5,458	34 (47)	5,458
Laboratory national hospital	21,478	132 (76)	21,478
Surveillance administration national hospital	1,614	10 (9)	1,614
Central surveillance administration (MoH)	6,600	41 ^d	6,600
National laboratory of reference	453,528	2,787 ^d	453,528
Total	677,215	11,542	1,951,562 (100%)

^a Mean costs per 100,000 population were calculated without considering urban/rural mean differences.

^b Standard deviation (SD) in brackets.

^c Country costs take into account different urban and rural averages and population weights. Share across administrative levels in brackets.

^d No SD as there was only one study element.

Table 4: Surveillance activities unit cost summary in Chad (2012 US\$).

Surveillance activity	Costs
Lumbar puncture per case	22
Transport of CSF from health centre to district laboratory per sample	5
District laboratory investigation per sample	13
Transport of CSF from district to national laboratory per sample	12
National laboratory investigation per positive sample	47
Transport of CSF to Oslo per sample	28
Oslo laboratory investigation per sample	95
Surveillance investigation per confirmed case	15
Reporting and analysis per suspected case	13
Supervision and feedback per suspected case	19

Online appendix

Figure 1: The African Meningitis Belt.

Source: WHO. Control of epidemic meningococcal disease, WHO practical guidelines, 1998, 2nd edition, WHO/EMC/BAC/98.3 in Malaria Vaccine Project. Epidemics in Africa : Periodic waves of meningitis epidemics occur across sub-Saharan Africa, wreaking havoc in the region. Available at <http://www.meningvax.org/epidemics-africa.php>, (accessed 20 August 20015).