**A Cost-Effectiveness Analysis of a National Program Implemented to Identify and Treat Schoolchildren with Correctable Refractive Error in Indonesia**

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**Introduction**

Through the larger *Seeing is Believing* (SiB) initiative by Standard Chartered Bank, which implements numerous programs worldwide seeking to identify, prevent, and treat visual impairment, Helen Keller International (HKI) launched a multi-phase initiative from 2016 to 2020 in conjunction with the Indonesian Ministry of Health (MoH) to build infrastructure for identifying and treating childhood visual impairment in Indonesia. Part of this initiative included a specific program, Opticians-in-Schools (OiS), that partnered with the district health and education offices, primary health workers, schoolteachers, community leaders, and refraction opticians to identify and provide glasses to schoolchildren with refractive error, at no cost. While previous school-based screening models have been implemented around the world with varied success, this study specifically evaluates the cost-effectiveness of designing and implementing a model that brings trained ophthalmic personnel and glasses to schools. Given the profound impact that visual impairment can have on quality of life, there is an urgent need for designing, deploying, and assessing cost-effective models for treating refractive error in children.

**Methods**

This observational study analyzes the costs, outcomes, and utility of OiS, a school-based visual acuity (VA) screening, refraction, and glasses delivery program implemented in South Sulawesi. South Sulawesi is a province in the southern peninsula of Sulawesi in Indonesia and includes twenty four districts. The OiS program was carried out in six districts: Makassar, Gowa, Bulukumba, Bone, Palopo, and Parepare. The program was designed and executed by Helen Keller alongside District health and education offices, professional associations, school administrators, and community leaders, with significant input and oversight from the Indonesian Ministry of Health. Study analysis was performed by HKI administrators in conjunction with researchers from the University of Michigan, USA, with removal of any and all identifiable health information prior to analysis. This analysis was designated as not regulated by the University of Michigan Institutional Review Board.

*Program Design*

The overarching goal of this Child Eye health program in Indonesia was to create multiple community outposts that could conveniently and cost-effectively serve as screening and triage centers for ocular diseases in children, given the limited access to Ophthalmologists in Indonesia. Such outposts included primary health centers (PHCs), maternal and child health posts (MCHPs), and schools. Teams of MoH experts, HKI personnel, professional ophthalmology associations, and Provincial and District Health Officers were responsible for identifying, orienting, and training those designated as a District Trainer (DT) for a given district in Indonesia. DTs were then responsible for orienting, training, and overseeing all personnel in their district. A flowchart outlining the relationships between screening and referral centers is depicted in Figure 1.

Within this larger Child Eye Health program, the OiS activity was enacted within schools across six districts in South Sulawesi to screen, refract, and provide glasses at no cost to schoolchildren with uncorrected refractive error. This activity is the focus of our cost-effectiveness analysis. Through OiS, DTs sensitized and trained nurses, who were subsequently deployed to train and oversee teachers performing VA screenings in schools. With coordination and assistance from Helen Keller, refraction opticians from the professional society (IROPIN) then visited schools at a later date to refract and provide glasses to students, with costs borne by Helen Keller. Given logistical constraints related to geography and graduating students, refraction services and glasses were provided centrally in two districts, Bone and Bulukumba.

*Data Definitions and Costs*

Our key metrics for this study included the costs associated with designing and implementing this program and the outcomes related to the results of VA assessments and glasses provision. Costs were organized into four *components*: **Sensitization, Training, Service Delivery,** and **Helen Keller Programming**:

* **Sensitization** referred to costs associated with introducing and orienting regional leadership and stakeholders from each district, such as district health officials, headmasters, PHC administrators, educators, with the program. This included coordinating necessary logistics and soliciting program support to solidify strong community partnership. When necessary, costs from the larger Child Eye Health program were disaggregated to only capture what was necessary to conduct the OiS program.
* **Training** referred to costs associated with ensuring all program personnel (DTs, nurses, administrators, teachers, etc.) received technical instruction and guidance on how to perform their individual roles.
* **Service Delivery** included all costs associated with performing screenings and refractions for schoolchildren. This included payment for specialized opticians to perform refraction and provide glasses. There were two primary models of Service Delivery: (i) one in which opticians traveled to schools to perform refractions and (ii) one in which schoolchildren were invited to a centralized location to receive refraction services. In the latter model, which was conducted in Bone and Bulukumba, costs associated with performing the refraction services centrally were instead aggregated.
* **Helen Keller Programming** encompassed additional internal costs borne by Helen Keller, the NGO with primary oversight for this project, in an effort to more reliably calculate the genuine costs associated with this initiative without volunteer assistance.

Within each *component* above, costs were assessed through the following expenditure categories, when applicable to that initiative: Labor, Honorariums, Meeting Packages, Eyeglasses, and Travel (Supplemental Table 1). Labor was calculated by utilizing publicly available government salary scales for civil workers[[1]](#footnote-1) at varying levels of experience. An hourly wage (assuming a 40-hour work week) was multiplied by the hours spent doing an activity, which was estimated from a combination of generated reports from schools following screenings and meeting itineraries from Helen Keller’s internal records. Honorariums, Meeting Packages (including facility fees, food, technology, and infrastructure costs) and Travel were calculated from itemized receipts available within Helen Keller’s internal records. Finally, Eyeglasses were calculated from a combined quote provided by IROPIN and paid for by Helen Keller for refraction services and spectacles, such that their specialized services remained profitable. On occasion, there were fixed program costs that were equally applicable to all districts; in these instances, costs were allocated in proportion to the number of students screened in that district.

*Inclusion and Exclusion Criteria*

Data from all students screened in middle schools (7th-9th grade) of the six aforementioned districts between August 2017 and March 2018 were included in the study. This included both *Costs* and *Outcomes* data, as outlined above. All *Outcomes* data submitted by schools underwent central auditing by Helen Keller and research personnel for accuracy and integrity. Schools were excluded from the analysis if they: did not provide screening data; closed during the study period; had students graduate prior to receiving refraction or glasses; or were found to provide inconsistent or unreliable data.

In the districts of Bone and Bulukumba, students presented to a centralized location within their district for refraction and glasses delivery, as opposed to the delivery of services and equipment to schools as performed in other districts. These occurred primarily due to geographical and logistical constraints, which necessitated a more expedited approach given that students with imminent graduation would become inaccessible. In these situations, costs associated with the centralized screening were still calculated, with adjustments in the Meeting Package and Travel categories as appropriate.

*Key Outcome Measures*

Outcomes for this study included the number of students and schools screened, the number of students that failed screening, the number of students and schools that received refractive services, and the number of students that received glasses. In conjunction with the costs outlined above, this information was used to generate the cost per student screened, cost per student refracted, and the cost per student receiving glasses as a measure of the cost-effectiveness of this program. Costs were provided in Indonesian Rupiah (IDR) and US dollars (USD), assuming an exchange rate of 14,200 IDR to 1 USD. Additionally, the cost per disability-adjusted-life-year (DALY) averted is also reported, with methodology outlined below.

*Cost-Utility Analysis*

A cost-utility sub-analysis was performed to calculate the cost per DALY averted by the OiS activity. There were multiple key assumptions for this sub-analysis:

* For estimated prevalence of uncorrected refractive error in South Sulawesi, instead of using the percentage of failed screenings in the cohort described above, we utilized a prevalence value of 18.4% based on additional screening activities conducted by Helen Keller in junior high schools in the province of South Sulawesi between 2019 and 2020.[[2]](#footnote-2) The reason for this was that the eyeglass distribution program described in this report utilized a VA screening threshold of <6/18. However, the <6/12 threshold used in the additional screening activities was deemed more relevant to current and future Helen Kelleractivities, while also corresponding to the WHO definition of “mild vision impairment”.
* In calculating disability weights, we first assumed the following vision impairment due to uncorrected refractive error severity breakdown based on the additional screening activities by *Helen Keller* in South Sulawesi: 67,1% with “mild” vision loss (VA 6/18 – 6/12), 12,1% with “moderate” vision loss (VA 6/60 – 6/18), 11,8% with “severe” vision loss (VA 3/60 – 6/60), and 9% with other eye conditions. We assumed that these other conditions are distributed proportionally across the severity spectrum.
* The disability weights themselves are taken from Global Burden of Disease (GBD) study models[[3]](#footnote-3),[[4]](#footnote-4). Considering the large difference in accepted GBD weights in 2016 and prior to 2010 for vision-related conditions, both were utilized in our analysis. For both measures, “mild” vision loss was assigned a value of 2/3 the value of “moderate” vision loss, given the lack of an assigned weight in GBD models. Cost per DALY averted are thus reported separately for pre-2010 and 2016 GBD weights.
* The expected useful life for a pair of glasses (accounting for noncompliance, lost or broken glasses and change in refractive error over time) was assumed to be 2 years, consistent with the range of values used in previous cost-effectiveness analyses and Helen Keller’s experience.[[5]](#footnote-5)
* The total cost of eyeglasses provided (part of Service Delivery costs) was adjusted proportionally to the difference in prevalence described above. While the cost per pair of glasses does not change, the assumed number of eyeglasses provided changes along with prevalence, thus affecting total eyeglasses costs.

**Results**

In total, 521 teachers were trained from 172 schools across six districts in South Sulawesi. A description of screening and refractive services provided by district are outlined in Table 1. Data from 41,212 students across 170 schools were screened and included in the study; two schools were excluded for missing or duplicate data. A total of 4,506 students (10.9%) failed the vision screening. Of these, 2,652 students from 148 schools were refracted by IROPIN’s refraction opticians, and 2,038 students from 145 schools were prescribed glasses and received them at no cost. The 1,854 (41.1%) students that failed their screenings but did not undergo refraction were lost to follow-up.

The total program costs allocated by Program Initiative and Expenditure Category at the district level can be found in Table 2a and Table 2b, respectively. At a program-wide level, the most cost-intensive program initiative was **Service Delivery** at IDR 676,606,522 ($47,648), which reflected 48.7% of all costs. This was followed by **Training** (29.5%), **Sensitization** (12.8%), and **Helen Keller Programming** (9.0%). When allocating by Expenditure Category, the highest cost was for Eyeglasses at IDR 549,766,000 ($38,716) reflecting 39.6% of all expenditures. This was followed by Meeting Packages (27.3%), Labor (23.3%), Travel (5.8%), and Honorariums (4.1%).

The cost-effectiveness metrics are outlined separately at the district level for school-based refraction services (Table 3a) and central refraction services (Table 3b). In school-based refraction districts (Makassar, Gowa, Palopo, Parepare), the cost per student screened was IDR 36,437 ($2.57), the cost per student refracted was IDR 444,873 ($31.33), and the cost per student receiving glasses was 587,838 ($41.40). By contrast, in central refraction districts (Bone and Bulukumba), the cost per student screened was slightly lower at IDR 29,018 ($2.04), while the cost per student refracted and cost per student receiving glasses were markedly higher at IDR 849,091 ($59.80) and IDR 1,039,786 ($73.22), respectively. Across all districts, the cost per student screened was IDR 33,708 ($2.37) and the cost per student receiving glasses was IDR 518,322 ($36.50).

Assuming a 2 year useful life cycle for a pair of glasses and an 18.4% prevalence of uncorrected refractive error in South Sulawesi (as observed in subsequent screening activities by *Helen Keller[[6]](#footnote-6)* ), the estimated cost per DALY averted was IDR 1,264,397($89.04) using pre-2010 GBD weights and IDR 5,933,441 ($417.85) using 2016 GBD weights.

**Discussion**

Through the OiS program, over 40,000 students were screened and over 2,000 students received glasses at no cost. The initiative required a coordinated effort between government officials from the district health and education offices, community leaders, teachers, administrators, healthcare professionals, and schoolchildren’s families, with a total cost of IDR 1,389,187,609 ($97,380). Approximately 11% of all students screened failed their screenings, with nearly 59% of those who failed screenings ultimately undergoing refraction. The other 41% were lost to follow-up, ~~likely~~ due to multiple factors. According to data from across *Helen Keller’s* OiS program[[7]](#footnote-7), the most common reason – accounting for 58.3% of lost follow-ups – was that students graduated between the time of initial screening and the time that refractive services were provided. Another 33.2% of lost follow-ups were due to students being absent the day that services were provided. Some students (6.4%) also moved to other schools before refractive services could be provided, and finally, 2.1% of lost follow-ups were due to students refusing refraction services.

Rates of loss to follow-up were comparatively high in Bone (68.7%) and Bulukumba (50.4%). In these districts, refraction services and glasses delivery were performed in a central location due to both logistical and transportation constraints, limited familial availability, and students’ impending graduation in these particular districts, necessitating expedited screening. It therefore was not surprising to us that the cost per student refracted and cost per student receiving glasses were markedly higher in these districts, as compared to the school-based refraction districts. Future iterations of this project may therefore seek to mitigate loss to follow-up while minimizing programmatic costs by adopting a local model of service delivery.

Within *Program components*, the largest cost was related to **Service Delivery**, which was expected given the limited availability and high demand for ophthalmic equipment and refraction specialists. Together, sensitization and training represented 42.5% of total program expenditures, which was not surprising since all actors were completely new to the program, and many had extremely limited knowledge of eye disease. Spending considerable time training and sensitizing community partners was paramount to efficient functioning in the pilot year. However, we suspect that future iterations of this program may result in reduced expenditures on *Sensitization and Training Initiatives*, given that many community partners, teachers, and administrative personnel have already been trained and may only require brief refresher trainings.

With respect to *Expenditure* categories, Eyeglasses represented the highest contributor to costs (39.8%). Notably, this cost for eyeglasses was quoted by IROPIN and reflected the price at which eyeglasses could be provided by the organization while still remaining profitable. Albeit higher, this pricing strategy facilitates a more sustainable approach that assists with determining the potential longevity of such a program. *Meeting Packages* was the next largest contributor (27.4%) and reflected all orientation, sensitization, training, and organizational meetings (many of which in-person) that took place in order to conduct the initiative. It is reasonable to expect that districts which were previously a part of OiS may require fewer meetings in the future.

Assuming a 18.4% prevalence of refractive error and a 2-year useful life cycle for a pair of glasses, the OiS initiative was estimated to cost $89.04 per DALY averted under pre-2010 GBD weights. This is consistent with a wide range of ophthalmic surgical interventions reported in a systematic review which suggested an average cost of $136 per DALY averted under pre-2010 GBD weights for ophthalmic surgery.[[8]](#footnote-8) The cost per DALY averted was notably higher for 2016 GBD weights, reflecting the profound and controversial decrease in disability weight attributable to visual impairment that reflects the non-fatal nature of most eye disease.[[9]](#footnote-9)

**Limitations**

There were limitations to this study. Data from screenings and refraction were primarily collected independently at schools and submitted to a central office for transcription, making the data sets susceptible to transcription errors or inaccuracies. To offset this, data underwent extensive centralized auditing by HKI employees in an effort to maintain data integrity. For instances in which there were significant inaccuracies or omissions from a given dataset, data from the entire school were excluded, which may have affected outcome metrics. There was considerable loss to follow-up in all districts. In some cases, students graduated and were unable to receive refraction services, which increased the rate of loss to follow-up and major outcome metrics, such as cost per student receiving glasses. However, additional efforts might be directed in future iterations of this program toward increasing follow-up rates, likely driving down the cost per student receiving glasses.

While many costs were calculated by reviewing itemized receipts from HKI, there were other costs that required estimating the time, resources, or fees associated with performing a given activity. For example, labor costs were estimated based on the pay for a standard workday as per government standardized salary scales, which may have varied based on the individual, school, district, or length of workday. As such, some costs represent estimates for conducting such a program, with key assumptions outlined in the methods after discussion with program leadership. Fixed program costs applying to the entire OiS initiative were evenly distributed by district based on number of students screened; this may have disproportionately allocated fixed costs to more efficient, higher throughput districts, but otherwise would not affect the bottom-line cost estimate for conducting the program in its entirety.

Finally, multiple assumptions were made in calculating the cost per DALY averted for the OiS activity. These assumptions, stated clearly in our methodology, are a necessary component for the calculation of such cost-effectiveness metrics. In particular, the prevalence of refractive error in South Sulawesi was found to be 18.4%, though variations in prevalence would likely affect the cost-effectiveness of such an endeavor.

**Conclusions**

This study outlined a cost-effectiveness analysis of a novel program, Opticians-in-Schools, implemented in six districts in South Sulawesi, Indonesia aimed at identifying and treating correctable refractive error in schoolchildren. Through this program, over 2,000 students received glasses free of charge, with a cost of $89.04 per DALY averted (under pre-2010 GBD weights. Given that a significant portion of costs were related to designing the structure, introducing the program to community leaders, and training personnel, future iterations could likely further reduce key cost metrics. Such programs, when deployed efficiently, have the potential to improving quality of life in schoolchildren with refractive error in settings with limited access to care though a cost-effective and safe intervention.

**Table 1:** Screening and Refraction Outcomes by District

*Note: Loss to follow-up rate represents the percentage of students that failed screening, yet did not receive glasses*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **School-Based Refraction** | | | | **Central Refraction** | |  |
| **Outcome Metric** | **Makassar** | **Gowa** | **Palopo** | **Parepare** | **Bulukumba** | **Bone** | **Total** |
| Schools Screened | 31 | 26 | 28 | 29 | 28 | 28 | 170 |
| Students Screened | 8,235 | 7,120 | 5,562 | 5,138 | 7,344 | 7,813 | 41,212 |
| Students Failing Screening | 1,363 | 826 | 505 | 646 | 837 | 329 | 4,506 |
| Schools Receiving Refraction | 30 | 25 | 24 | 24 | 25 | 20 | 148 |
| Students Refracted | 985 | 417 | 330 | 402 | 415 | 103 | 2,652 |
| Loss to Follow-Up (%) | 27.7% | 49.5% | 34.7% | 37.8% | 50.4% | 68.7% | 41.1% |
| Schools Receiving Refraction + Glasses | 30 | 24 | 24 | 24 | 24 | 19 | 145 |
| Students Receiving Refraction + Glasses | 770 | 230 | 275 | 340 | 336 | 87 | 2,038 |
| ***% share of fixed costs*** | ***20%*** | ***17%*** | ***13%*** | ***12%*** | ***18%*** | ***19%*** |  |

**Table 2a: District-Level Total Costs, by Program Initiative**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **School-Based Refraction** | | | | **Central Refraction** | |  |
| **Program Initiative** | **Makassar** | **Gowa** | **Palopo** | **Parepare** | **Bulukumba** | **Bone** | **Cost (IDR)** |
| Sensitization | 29,690,327 | 29,130,283 | 23,042,122 | 21,438,867 | 38,015,316 | 36,334,067 | 177,650,982  ($12,511) |
| Training | 101,584,910 | 73,750,310 | 44,145,591 | 37,902,301 | 67,830,030 | 84,474,712 | 409,687,855  ($28,851) |
| Service Delivery | 199,193,954 | 97,721,350 | 97,076,907 | 115,500,902 | 118,817,415 | 48,295,994 | 676,606,522  ($47,648) |
| HKI Programming | 25,025,962 | 21,637,504 | 16,902,781 | 15,614,255 | 22,318,235 | 23,743,514 | 125,242,250  ($8,820) |
| Total Cost | 355,495,153 | 222,239,448 | 181,167,401 | 190,456,325 | 246,980,995 | 192,848,287 | 1,389,187,609  ($97,380) |

*Note: Costs are presented in IDR unless otherwise specified*

**Table 2b: District-Level Total Costs, by Expenditure Categories**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **School-Based Refraction** | | | | **Central Refraction** | | |  | |
| **Expenditure Category** | **Makassar** | **Gowa** | **Palopo** | **Parepare** | **Bulukumba** | **Bone** | **Cost (IDR)** | |
| Labor | 71,024,780 | 56,200,518 | 40,651,339 | 38,020,303 | 55,830,876 | 61,944,493 | 323,672,309  ($22,794) | |
| Honorarium | 13,600,000 | 10,800,000 | 5,600,000 | 4,000,000 | 10,400,000 | 12,000,000 | 56,400,000  ($3,972) | |
| Meeting Packages | 84,349,055 | 66,150,695 | 43,455,914 | 38,549,948 | 69,189,024 | 77,556,163 | 379,250,800  ($26,708) | |
| Eyeglasses | 170,516,000 | 75,250,000 | 80,650,000 | 99,900,000 | 97,287,500 | 26,162,500 | 549,766,000  ($38,716) | |
| Travel | 16,005,318 | 13,838,234 | 10,810,149 | 9,986,074 | 14,273,595 | 15,185,130 | 80,098,500  ($5,641) | |

*Note: Costs are presented in IDR unless otherwise specified*

**Table 3a: Cost-Effectiveness in Districts with School-Based Refraction Services (Makassar, Gowa, Palopo, Parepare)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Outcome** | **Makassar** | **Gowa** | **Palopo** | **Parepare** | **Total (IDR)** |
| Cost per Student Screened | 43,169 | 31,213 | 32,572 | 37,068 | 36,437 ($2.57) |
| Cost per Student Refracted | 360,909 | 532,948 | 548,992 | 473,772 | 444,873 ($31.33) |
| Cost per Student Receiving Glasses | 461,682 | 966,258 | 658,791 | 560,166 | 587,838 ($41.40) |

*Note: Costs are presented in IDR unless otherwise specified*

**Table 3b: Cost-Effectiveness in Districts with Central Refraction Services (Bone and Bulukumba)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Metric** | **Bulukumba** | **Bone** | **Total** |
| Cost per Student Screened | 33,630 | 24,683 | 29,018  ($2.04) |
| Cost per Student Refracted | 595,135 | 1,872,313 | 849,091  ($59.80) |
| Cost per Student Receiving Glasses | 735,062 | 2,216,647 | 1,039,786  ($73.22) |

*Note: Costs are presented in IDR unless otherwise specified*

**Supplemental Table 1: Categorization of Program Costs**

|  |  |
| --- | --- |
| **Program Initiatives** | **Expenditure Categories** |
| Sensitization | Labor |
| Training | Honorariums |
| Service Delivery | Meeting Packages |
| HKI Programming | Eyeglasses |
|  | Travel |

**Figure 1: Seeing Is Believing Referral Center Flowchart**

**Diagram

Description automatically generated**

**Figure 2a: Cost per Student Receiving Glasses at District Level, Allocated by Program Initiative**

**Figure 2b: Cost per Student Receiving Glasses at District Level, Allocated by Expenditure Category**

1. Government Regulation (PP) RI Number 15 of 2019 concerning the Eighteenth Amendment to Government Regulation Number 7 of 1977 concerning Salary Regulations for Civil Servants [↑](#footnote-ref-1)
2. Helen Keller Program Reports, 2020. [↑](#footnote-ref-2)
3. World Health Organization. Global Burden of Disease 2004 Update: Disability Weights for Diseases and Conditions. WHO Geneva; 2004. www.who.int/healthinfo/global\_burden\_disease/GBD2004\_DisabilityWeights.pdf [↑](#footnote-ref-3)
4. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Supplementary Appendix 1. Lancet 2017; 390: 1211–59. [↑](#footnote-ref-4)
5. Angell B, Ali F, Gandhi M, et al. Ready-made and custom-made eyeglasses in India: a cost-effectiveness analysis of a randomised controlled trial. BMJ Open Ophthalmology 2018;3:e000123. [↑](#footnote-ref-5)
6. Helen Keller Program Reports, 2020 [↑](#footnote-ref-6)
7. Helen Keller program data, 2018 [↑](#footnote-ref-7)
8. Chao, Tiffany E., Ketan Sharma, Morgan Mandigo, Lars Hagander, Stephen C. Resch, Thomas G. Weiser, and John G. Meara. “Cost-Effectiveness of Surgery and Its Policy Implications for Global Health: A Systematic Review and Analysis.” *Lancet. Global Health*. 2014;2(6):: e334-345. [↑](#footnote-ref-8)
9. Taylor HR, Jonas JB, Keeffe J, Leasher J, Naidoo K, Pesudovs K, Resnikoff S. Disability weights for vision disorders in Global Burden of Disease study. Lancet. 2013 Jan 5;381(9860):23. [↑](#footnote-ref-9)