Cost and budget impact of mass drug administration compared to expanded school-based targeted preventive chemotherapy for soil-transmitted helminth control in Zamboanga Peninsula, the Philippines

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Summary

Background School-based targeted preventive chemotherapy (PC), the primary strategy for soil-transmitted helminth (STH) control, typically focusing on primary schoolchildren, was expanded to secondary school students in the Philippines in 2016. This program still excludes adults, who may also suffer from considerable morbidity and can be a significant reservoir of infection. Mass drug administration (MDA), where the entire population is treated, would bring additional health benefits but will also increase implementation costs. The incremental cost of implementing MDA for STH control compared to expanded school-based targeted PC, however, is unknown.

Methods A cost survey was conducted in Zamboanga Peninsula region in 2021 to estimate the economic and financial cost of implementing MDA compared to the expanded school-based targeted PC from a government payer perspective. A budget impact analysis was conducted to estimate the financial cost to the government of implementing MDA over a five-year timeframe. Monte Carlo simulation accounted for uncertainty in cost estimates. Costs were reported in 2021 United States Dollars ($).

Findings The economic cost of MDA was $809,000 per year (95% CI: $679,000–$950,000) or $0.22 per person targeted (95% CI: $0.19–$0.26), while the expanded school-based targeted PC would cost $625,000 (95% CI: $549,000–$706,000) or $0.57 per person targeted (95% CI: $0.50–$0.64). Over five years, the financial cost to the government for MDA would be $3,113,000 (95% CI: $2,475,000–$3,810,000); $740,000 (95% CI: $486,000–$1,019,000) higher than expanded school-based targeted PC.

Interpretation Implementing MDA in the region will increase the economic and financial costs by 29% and 31%, respectively, when compared to expanded school-based targeted PC. Implementing MDA would require the Department of Health to increase their total expenditure for STH control by 0.2% and could be key in addressing the ongoing STH burden.

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Keywords: Soil-transmitted helminths; Expanded school-based targeted preventive chemotherapy; Mass drug administration; Cost analysis; Cost survey; Budget impact analysis; Philippines

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Research in context

Evidence before this study

We searched the literature for cost analyses of preventive chemotherapy (PC) for soil-transmitted helminths (STH) control published after the year 2000. Twenty-two published studies and one unpublished study reported the cost for school-based targeted PC or mass drug administration (MDA) for STH control with or without integration with PC for other neglected tropical diseases (NTDs). Of those, six were conducted in Southeast Asia, specifically in Cambodia, Lao PDR, the Philippines, Myanmar, and Vietnam (one published and one unpublished); and only two, a study conducted in India, Malawi, and Benin, and an unpublished cost survey in Vietnam compared the cost of school-based targeted PC and MDA for STH control alone. Of these, only the cost survey conducted in India reported the cost of expanded school-based targeted PC covering children ages 1–19 years.

Added value of this study

Our study showed that implementing MDA will incur 29% and 31% incremental economic and financial costs, respectively, when compared with the expanded school-based targeted PC, and that the per person cost for MDA is less than half of that for the expanded school-based targeted PC. This study is the first globally to provide economic and financial cost estimates based on government program data for MDA and the expanded school-based targeted PC covering children ages 5–18 years, and the first to provide the budget impact of implementing MDA instead of the expanded school-based targeted PC. This is also only the second study globally to utilise Monte Carlo simulation to account for uncertainty in cost category estimates for PC for STH control.

Implications of all the available evidence

The 31% incremental financial cost of implementing MDA and the much lower cost per person at-risk for MDA makes it an affordable alternative to the expanded school-based targeted PC that could potentially address the persistent STH burden unreached by the current strategy, particularly in adults.

Introduction

More than 900 million people globally and 168 million people in the Western Pacific were infected with soil-transmitted helminths (STH) in 2019.[1] STH species include *Ascaris lumbricoides*, *Trichuris trichiura*, and the hookworm species *Necator americanus*, *Ancylostoma duodenale*, and *Ancylostoma ceylanicum*. Moderate-to-heavy intensity STH infections have been linked to anaemia and inadequate growth and development, especially among children and women of reproductive age.[2] STH infections are the most common of the neglected tropical diseases (NTDs). Globally, in 2019, an estimated two million disability-adjusted life years (DALYs) were lost due to STH of which 225,000 DALYs were lost in the Western Pacific.[1]

The World Health Organisation (WHO) aims to eliminate STH infections as a public health problem by 2030, defined as less than 2% prevalence of moderate-to-heavy intensity STH infections.[3] School-based targeted preventive chemotherapy (PC) is the primary strategy recommended to reach this goal.[3] Under this approach, anthelmintics are administered without prior diagnosis to children attending primary school (typically 5–12 years of age),[2] either annually or biannually, based on the prevalence of STH infections.[3] The use of the school infrastructure and staff has been considered an efficient method to deliver anthelmintics,[4] to decrease STH morbidity among infected children,[2] and cost-effective compared to a “do-nothing” approach.[5,6] However, given that adults also bear a significant burden of infection, particularly in settings where hookworm predominates, mass drug administration (MDA), which involves treating everyone in a community above the age of one year, has been suggested as an alternative to school-based targeted PC.[7,8] MDA is the strategy used for control and elimination of other NTDs, including lymphatic filariasis, onchocerciasis and trachoma.[9–11] Evidence from mathematical modelling,[8,12] and meta-analysis,[7] suggest that MDA for STH control is more effective in reducing STH prevalence than school-based targeted PC. There were also limited evidence from experimental studies,[13,14] suggest reduced odds of *N. americanus* infections for those receiving MDA compared to school-based targeted PC[13] and that MDA was more effective in reducing overall hookworm prevalence and intensity than school-based treatment.[14] In addition, the CoDe-STH Trial showed that MDA resulted in a greater relative reduction in *N. americanus* infection intensity and prevalence of moderate-to-heavy intensity of *N. americanus* infections compared to school-based targeted PC.[15] However, there is evidence from Benin, India, Malawi and Vietnam that total costs associated with MDA are three to four times higher than school-based targeted PC as more resources such as personnel are required to treat the entire population.[16,17]

In the Philippines, biannual school-based targeted PC has been implemented since 2006 as part of the Integrated Helminth Control Program.[18] In 2015, the national prevalence of moderate-to-heavy STH infections in schoolchildren was 9%,[19] well above the 2% WHO target,[3] and a similar burden was found among secondary school students in two provinces.[20] In 2016, school-based targeted PC was expanded to also include secondary school students, which from hereon we refer to as expanded school-based targeted PC. To our knowledge, the expanded school-based targeted PC, which covers students 5–18 years of age,[21] is only implemented in the Philippines. This strategy, however, still does not cover adults where heavy STH burden persists.[22] MDA could be an alternative to address the remaining STH burden. It is not known, however, how the cost of MDA compares with the expanded school-based targeted PC. While there were seven cost surveys in Southeast Asia that reported the cost of school-based targeted PC or MDA for STH [17,23–28]; none compared the expanded school-based targeted PC with MDA.

We conducted a comprehensive cost and budget impact analysis in the Zamboanga Peninsula region in Southern Philippines, comparing MDA and the expanded school-based targeted PC involving annual treatment with albendazole. The region was selected because in one province, Zamboanga del Norte, MDA with albendazole and diethylcarbamazine has been implemented since 2001 for lymphatic filariasis elimination as a public health problem and for STH control,[29] while expanded school-based targeted PC is implemented in all provinces,[21] therefore providing an opportunity to compare the cost of expanded school-based targeted PC with MDA for STH control using government program data. We only estimated costs for MDA for STH, and not for lymphatic filariasis. We also did not aim to estimate the efficiency or cost-effectiveness of either approach. This study will provide valuable information to governments and funding agencies when considering PC for STH control.

Methods

Setting

Zamboanga Peninsula, an administrative region is Southern Philippines, is composed of three provinces, Zamboanga del Norte, Zamboanga del Sur, and Zamboanga Sibugay, and one highly urbanised city, Zamboanga City. Provinces and highly urbanised cities are the highest levels of local governments. Provinces are divided into cities or municipalities, in turn divided into *barangays* or villages.[30] In 2014, the prevalence of any STH was 27% and of moderate-to-heavy STH was 8%.[19] In 2021, the region had a population of 3,774,448;[31] of whom 1,189,159 were 5–18 years of age (Nieto Fernandez, Philippine Department of Health, personal communication).

Cost survey

Questionnaires developed for a cost survey comparing MDA with school-based targeted PC in Vietnam[17] were adapted to collect cost and resource use data from the participants for the implementation of MDA and expanded school-based targeted PC for STH control for one year. A government payer perspective was used, where only the costs incurred by the government were considered.

Costs categories were defined according to major activities related to PC implementation[14,16,17,32]: albendazole procurement (which includes its purchase, transport, and storage), training, community sensitisation, albendazole administration, PC monitoring and evaluation, and program running (Table 1). The questionnaires were translated from English to local languages in use in the study area, *Filipino*, *Bisaya*, and *Chavacano*, and were pre-tested with the staff of the regional Department of Health. Resource savings associated with reductions in STH infection cases were not considered due to a lack of data on STH morbidity-related health service utilisation and STH prevalence reduction.

From each of the selected provinces (Zamboanga del Norte, Zamboanga del Sur) or highly urbanised city (Zamboanga City), a city and a municipality were selected, from which in turn, one village was selected; ensuring that all administrative levels were considered (Fig. 1). The sites were selected purposively in consultation with the regional Department of Health and the concerned local governments. Participants included the staff in charge of expanded school-based targeted PC for STH or MDA for lymphatic filariasis in the regional Department of Health; in the provincial, city, and municipal governments; and in the regional, provincial, city, and municipal levels of the Department of Education, a partner agency in the implementation of expanded school-based targeted PC. In each selected village the clinic teacher, who oversees students' health in the village school, and the rural health midwife, the only full-time health worker assigned to the village health station, were also interviewed. The interviews were conducted in *Filipino* or local languages from 24 November to 10 December 2021 by JPCDT, assisted by regional Department of Health personnel (NF, AG, SV, and CAO) who translated the questions to *Bisaya* and *Chavacano* and responses to *Filipino* as needed. The data collection was conducted five years after the implementation of expanded school-based targeted PC. While the MDA program that was costed in Zamboanga del Norte involved the co-administration of diethylcarbamazine and albendazole; we only estimated costs for MDA for STH, and not for lymphatic filariasis. Of note is that most of the costs incurred by the government would be similar regardless of the number of drugs administered. For instance, for transport costs for field teams, the number of drugs provided would be the same. On the other hand, some costs need to be adjusted depending on the number of drugs. For instance, when eliciting the time needed by health workers needed to implement MDA, we only asked for the time that the health workers needed in administering albendazole for STH, and not with the co-administration with diethylcarbamazine.

Questionnaire responses were translated to English and entered into a Microsoft Excel spreadsheet. Data from the survey were complemented by online sources as required. For each cost item, the average and the

Category[a]	Description
Albendazole procurement	expenses incurred in the 1) purchase, 2) storage, and 3) transport (from the national government to the village) of albendazole
Training	training of teachers and health workers for expanded school-based targeted preventive chemotherapy and of health workers for MDA; includes expenses for the participants' allowance and training kits and the expenses in hosting the training
Community sensitisation	expenses incurred for increasing awareness and improving participation to the preventive chemotherapy; divided into 1) radio ad, 2) banners, 3) posters, 4) flyers, 5) orientation of parents[b], and 6) orientation of children[b]
Albendazole administration	expenses incurred in the administration of albendazole in the school or community; divided into: 1) personnel, 2) supplies, and 3) equipment. For expanded school-based targeted PC, the cost of snacks, toothbrush, toothpaste, and soap, which are supplies provided during PC implementation in the Philippines, were not included in this analysis.
PC monitoring and evaluation	expenses incurred for monitoring and evaluation of PC implementation; divided into 1) PC day monitoring; 2) submission of PC reports[b], 3) parasitological assessment, and 4) data management
Program running	expenses incurred in maintaining the STH control program; divided into 1) program staff, 2) supplies and equipment, and 3) office space and utilities

Abbreviations: MDA, mass drug administration; PC, preventive chemotherapy; STH, soil-transmitted helminths. [a]Start-up costs are incorporated in training and community sensitisation while no additional staff are expected to be hired. [b]Orientation of children and parents and submission of PC reports do not incur financial cost because no additional salaries, supplies, or equipment are paid for to conduct these activities.

Table 1: **Cost categories for the cost analysis.**

range were compiled (Appendix pp 2–14). Straight-line depreciation was applied to all equipment, assuming an expected life of 10 years based on useful life of equipment indicated in the Philippine Commission on Audit Circular No. 2003-007.[33] Prices in Philippine Pesos (PHP) were adjusted when necessary to the Year 2021 using the consumer price index,[34] and then converted to United States Dollars ($ 1 = PHP 49.28).[35]

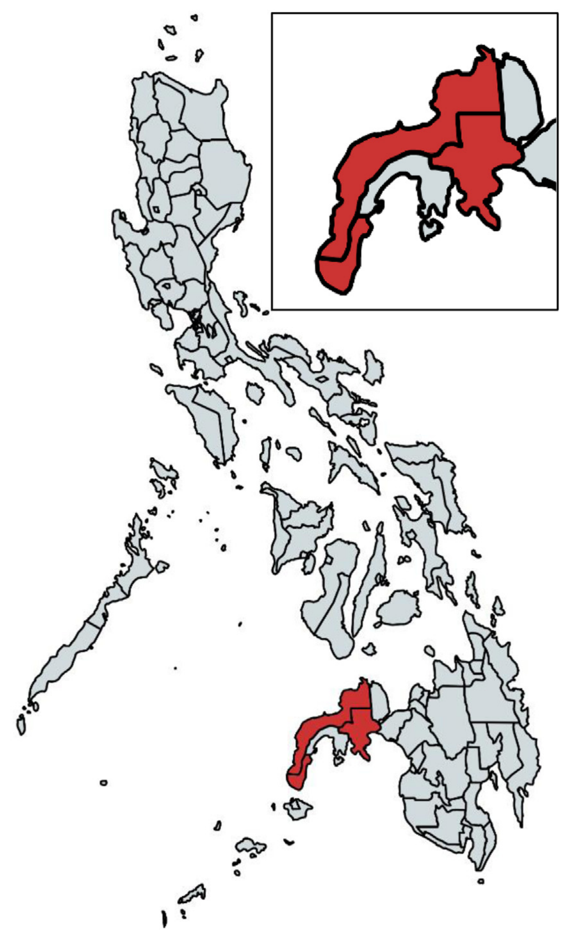

Fig. 1: **Map of the Philippines showing in red the provinces in Zamboanga Peninsula where this study took place: Zamboanga del Norte (left), Zamboanga del Sur (right), and Zamboanga City (bottom).**

Cost and budget impact analyses

Both economic and financial costs were estimated. The economic cost includes the full value of all resources used in delivering an intervention,[36] and includes both the financial and opportunity costs. The financial cost includes expenditure for products or service purchased[37] but does not include opportunity costs. Opportunity costs are the value of goods or services that may have been donated.[36] Salary costs by occupation were estimated by converting the monthly salary of the staff to a per-hour rate and then multiplying it by the time engagement and the number of staff involved.

A cost model developed for a cost survey in Vietnam using TreeAge Pro Healthcare (TreeAge Software, LLC)[17] was adapted to the Philippines context to calculate the annual total and per person economic cost and financial costs of each strategy and to account for uncertainty (Fig. 2). The same model was used to perform a budget impact analysis estimating the financial impact to the government of implementing annual MDA in Zamboanga Peninsula, instead of the annual expanded school-based targeted PC, for five years. The cost model included six branches, corresponding to the cost categories and respective subcategories (Fig. 2). For each subcategory, the uncertainty in the cost estimate was assumed to follow a triangular distribution, with the peak and range of the distribution corresponding to the average, lowest, and highest cost estimates calculated using the data from the cost survey and online sources (Appendix pp 15–16). Uncertainty across cost items was assumed independent, and values from each triangular distribution were drawn independently for each cost subcategory. The cost per person at-risk was calculated by dividing the total cost by the population in the

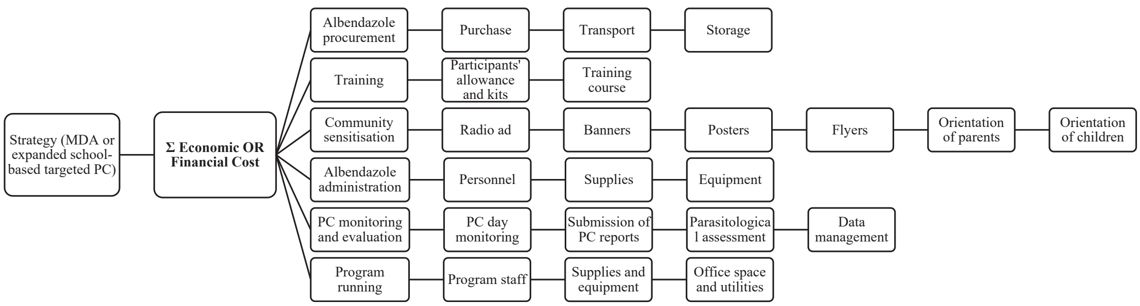

Fig. 2: **Cost model used for Monte Carlo simulation**. Abbreviations: MDA, mass drug administration; PC, preventive chemotherapy.

region[31] for MDA and by the number of enrolled students 5–18 years of age (Nieto Fernandez, Philippine Department of Health, personal communication) for expanded school-based targeted PC. The model was separately populated with economic and financial costs. Monte Carlo simulations (10,000 iterations) were performed to derive the mean and 95% credible interval (CI). All total costs were rounded to the nearest thousand dollars for ease of reporting. For the budget impact analysis, the costs were not discounted as recommended in guidelines.[38] The proportion of iterations where a strategy is more costly based on the per person cost and on total cost was also obtained.

Two alternative scenarios in the analysis for both MDA and the expanded school-based targeted PC were explored. First, examining if PC was implemented biannually; and second using the monthly minimum wage of PHP 7272-PHP 7584 ($148–$154) in Zamboanga Peninsula for village health workers instead of their current monthly allowance of PHP 1000-PHP 1500 ($ 20.29–$30.44).

Ethical considerations
This study received ethics approval from the Human Research Ethics Committee at the University of New South Wales (HC210243) and by the Zamboanga Consortium for Health Research and Development—Research Ethics Review Committee (EC2021-004-03).

Role of funding source
The organisations which funded the study had no role in the research design; in the collection, analysis, and interpretation of data; in the preparation of the manuscript; and in the decision to submit the manuscript to be considered for publication.

Results
Cost survey
A total of 28 respondents participated in the cost survey. These included the staff in charge of PC for STH in the regional Department of Health (N = 1); in the regional (N = 1), provincial (N = 3), and municipal (N = 4) Department of Education; and the provincial (N = 3) and municipal health offices (N = 4) (Fig. 3). In Zamboanga del Norte, the respondents also included the staff in charge of MDA for lymphatic filariasis from the Department of Health (N = 1) and from the provincial health office (N = 1). Lastly, five clinic teachers and five rural health midwives were also interviewed (Fig. 3). The collated responses of the respondents concerning cost and resource use are shown in Appendix pp 2–14. The average and the range of cost for each subcategory are shown in Appendix p 15 for economic cost and Appendix p 16 for financial cost.

Cost and budget impact analyses
The estimated total annual economic cost of implementing MDA was $809,000 (95% CI: $679,000–$950,000), with a cost of $0.22 per person (95% CI: $0.19–$0.26); whereas the economic cost of implementing annual expanded school-based targeted PC was $625,000 (95% CI: $549,000–$706,000) with a cost per person at-risk of $0.57 (95% CI: $0.50–$0.64) (Table S2, Appendix p 20). Albendazole administration accounted for almost half of the economic cost for both strategies, albeit with large differences in cost due to more personnel needed for MDA (Table 2). In terms of relative contribution to the total economic cost, albendazole administration (48% for MDA and 47% for expanded school-based targeted PC), training (5% for both strategies), and program running (8% for MDA and 10% for expanded school-based targeted PC) were similar for the two strategies (Table 2). Albendazole procurement (13% for MDA and 6% for expanded school-based targeted PC) and PC monitoring and evaluation (10% for MDA and 4% for expanded school-based targeted PC) accounted for a larger portion of the total economic cost for MDA than with expanded school-based targeted PC (Table 2). The opposite is true for community sensitisation (22% for MDA and 35% for expanded school-based targeted PC) (Table 2).

The total annual financial cost of MDA was $623,000 (95% CI: $495,000–$762,000), which was higher than that of expanded school-based targeted PC, estimated to be $474,000 (95% CI: $397,000–$557,000) (Table S3,

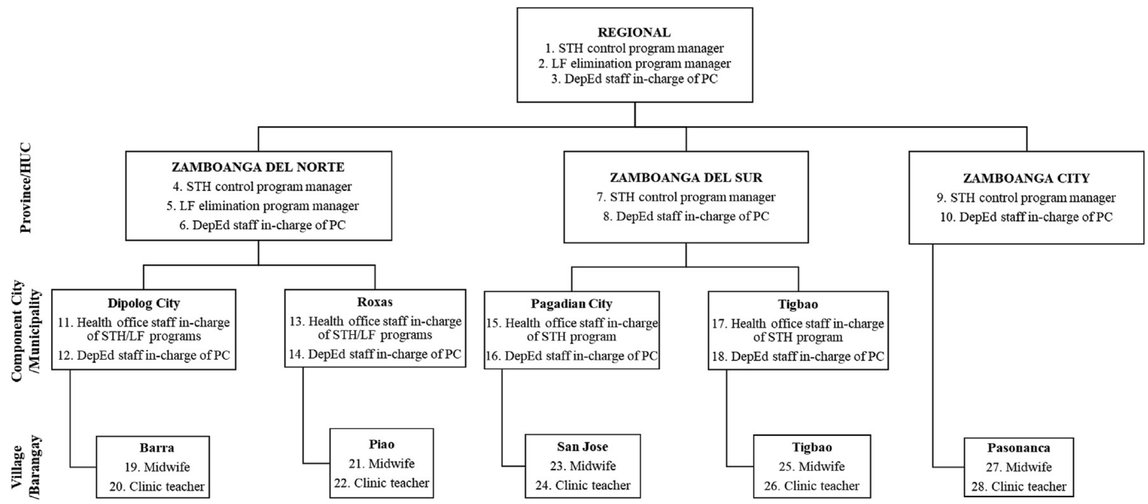

***Fig. 3:* Cost survey respondents**. Abbreviations: DepEd, Department of Education; HUC, highly urbanised city; LF, lymphatic filariasis; STH, soil-transmitted helminths; PC, preventive chemotherapy.

Appendix p 21). Albendazole administration accounted for majority of the financial cost for both strategies (Table 3). In terms of relative contribution to the total financial cost, albendazole administration (61% for both strategies) and training (7% for both strategies) were similar for the two strategies (Table 3). Albendazole procurement accounted for a larger portion of the total financial cost for MDA (16%) than with expanded school-based targeted PC (8%) (Table 3). The opposite is true for community sensitisation (13% for MDA and 20% for expanded school-based targeted PC) (Table 3).

Proportions of expenditure were consistent between the financial and economic costs. The only difference was PC monitoring and evaluation which accounted for a similar proportion of the total financial cost for the two strategies (3% for MDA and 4% for expanded school-based targeted PC). The financial costs of MDA and expanded school-based targeted PC were 23% and 24%, respectively, lower than their corresponding economic costs. The higher economic costs were driven by utilising pre-existing resources and thus not paid for, such as storage for albendazole, equipment used by health workers, and program running expenses. The Monte Carlo simulation showed that the economic and financial cost per person at-risk of MDA is lower than the expanded school-based targeted PC in all iterations.

Switching from expanded school-based targeted PC to MDA in the region would increase the cost to the government by $148,000 (95% CI: –$5000 to $310,000) per year (Table 3). Most of the increase in cost was in the purchase cost of albendazole as part of albendazole procurement at $61,000 (95% CI: $53,000–$69,000) and personnel for albendazole administration at $103,000 (95% CI: –$17,000 to $262,000) (Table 3). Implementing MDA would result in savings in community sensitisation of $15,000 (95% CI: –$7000 to $37,000) and supplies for albendazole administration of $9000 ($1000–$18,000) (Table 3). Implementing MDA over five years would cost $3,113,000 (95% CI: $2,475,000–$3,810,000), while expanded school-based targeted PC in the region would cost $2,368,000 (95% CI: $1,983,000–$2,786,000). For that period, the incremental financial cost of changing to MDA would be $740,000 (95% CI: $486,000–$1,019,000).

Scenario analyses

When biannual MDA and biannual expanded school-based targeted PC were considered, the per person economic cost for MDA decreased from the base case of $0.22 (95% CI: $0.19–$0.26) to $0.20 (95% CI: $0.17–$0.24). The per person economic cost for expanded school-based targeted PC also decreased from $0.57 (95% CI: $0.50–$0.64) to $0.50 (95% CI: $0.44–$0.57) (Appendix p 17). MDA costs less per person in all the iterations of the Monte Carlo simulation. Biannual MDA would result in a yearly financial cost of $1,158,000 (95% CI: $903,000–$1,432,000), while for biannual expanded school-based targeted PC, the total yearly financial cost would be $868,000 (95% CI: $718,000–$1,028,000) (Appendix p 18). Biannual MDA in Zamboanga Peninsula would increase the cost to the government by $290,000 (95% CI: –$12,000 to -$608,000) an increase in spending of 33% every year when compared to biannual expanded school-based targeted PC (Appendix p 18). It was estimated that the five-year implementation of biannual MDA would cost $5,788,000 (95% CI: $4,515,000–$7,162,000), while the expanded school-based targeted PC in the region would cost $4,339,000 (95% CI: $3,592,000–$5,140,000) (Appendix p 18).

Cost categories	Cost estimates			
	Mass drug administration		Expanded school-based preventive chemotherapy	
	Mean (%)	95% CI	Mean (%)	95% CI
Albendazole procurement	**107,000 (13)**	**96,000–119,000**	**39,000 (6)**	**34,000–44,000**
Purchases	89,000 (11)	83,000–94,000	28,000 (4)	26,000–29,000
Transport	8000 (1)	7000–11,000	9,000 (1)	7000–11,000
Storage	10,000 (1)	6000–15,000	2000 (0)	1000–3000
Training	**42,000 (5)**	**17,000–69,000**	**34,000 (5)**	**15,000–54,000**
Participants' allowance and kits	34,000 (4)	14,000–53,000	21,000 (3)	9000–33,000
Training course	8000 (1)	3000–16,000	13,000 (2)	6000–21,000
Community sensitisation	**180,000 (22)**	**153,000–209,000**	**217,000 (35)**	**185,000–250,000**
Radio ad	6000 (1)	3000–10,000	6000 (1)	3000–10,000
Banners	43,000 (5)	36,000–50,000	54,000 (9)	45,000–63,000
Posters	15,000 (2)	13,000–17,000	11,000 (2)	10,000–13,000
Flyers	17,000 (2)	15,000–18,000	24,000 (4)	22,000–26,000
Orientation-parents	100,000 (12)	86,000–113,000	111,000 (18)	96,000–127,000
Orientation-children	0 (0)	0–0	10,000 (2)	9000–11,000
Albendazole administration	**389,000 (48)**	**259,000–530,000**	**292,000 (47)**	**211,000–378,000**
Personnel	370,000 (46)	244,000–506,000	266,000 (43)	193,000–344,000
Supplies	15,000 (2)	11,000–19,000	25,000 (4)	17,000–33,000
Equipment	4000 (0)	4000–4000	1000 (0)	1000–1000
PC monitoring and evaluation	**79,000 (10)**	**52,000–107,000**	**25,000 (4)**	**22,000–29,000**
PC day monitoring	16,000 (2)	15,000–17,000	16,000 (3)	15,000–17,000
Submission of PC reports	58,000 (7)	33,000–85,000	5000 (1)	3000–6000
Parasitological assessment	3000 (0)	3000–4000	3000 (1)	3000–4000
Data management	1000 (0)	1000–2000	1000 (0)	1000–2000
Program running	**64,000 (8)**	**60,000–69,000**	**64,000 (10)**	**60,000–69,000**
Program staff	32,000 (4)	30,000–33,000	32,000 (5)	30,000–33,000
Supplies and equipment	14,000 (2)	13,000–15,000	14,000 (2)	13,000–16,000
Office space and utilities	18,000 (2)	17,000–20,000	18,000 (3)	17,000–20,000
Total cost	**809,000**	**679,000–950,000**	**625,000**	**549,000–706,000**
Cost per persoñ	**0.22**	**0.19–0.26**	**0.57**	**0.50–0.64**

Abbreviations: 95% CI: 95% credible interval (CI), i.e., the range where the results of 95% of the iterations fall. [a]Values based on the Monte Carlo simulation conducted using data obtained from the cost survey, costs in PHP adjusted to 2021 using consumer price index; and converted to $ (rate: $1 = PHP 49.28). The cost per person targeted was calculated by dividing the total cost by the population in the region[31] for MDA (3,774,448) and by the number of enrolled students 5–18 years of age for expanded school-based targeted PC. (1,189,159).

Table 2: **Economic cost of mass drug administration and expanded school-based targeted preventive chemotherapy in Zamboanga Peninsula, Philippines based on Monte Carlo simulation.[a]**

If the village health workers were paid the minimum monthly wage in Zamboanga Peninsula instead of their current allowance, the economic cost per person at-risk would increase to $0.34 (95% CI: $0.28–$0.40) for MDA and $0.59 (95% CI: $0.58–$0.66) for expanded school-based targeted PC, with MDA having a lower economic cost per person at-risk in all the iterations (Appendix p 19). In this scenario, the economic cost of MDA in the region will be $1,250,000 per year (95% CI: $1,019,000–$1,501,000), which is 55% higher than the base case. On the other hand, the expanded school-based targeted PC will cost $655,000 (95% CI: $574,000–$740,000) (Appendix p 19), which is 5% higher than the base case.

Discussion

We present the findings from the first cost and budget impact analysis comparing MDA to the expanded school-based targeted PC, covering schoolchildren ages 5 to 18 currently in place in the Philippines.

The total annual economic cost of MDA ($809,000) is 29% higher than the expanded school-based targeted PC ($625,000). This incremental cost is much lower than those observed in Vietnam, Benin, India and Malawi, where MDA costs 300–400% more than school-based targeted PC.[16,17] The same is true for financial cost, where MDA in Zamboanga Peninsula region costs 31% more than the expanded school-based targeted PC, compared to a 400% increase in

Cost categories	Cost estimates					
	Mass drug administration		Expanded school-based preventive chemotherapy		Financial impact of mass drug administration[b]	
	Mean (%)	95% CI	Mean (%)	95% CI	Mean (%)	95% CI
Albendazole procurement	**97,000 (16)**	**90,000–104,000**	**36,000 (8)**	**33,000–40,000**	**61,000**	**53,000–69,000**
Procurement	89,000 (14)	83,000–94,000	28,000 (6)	26,000–29,000	61,000	55,000–66,000
Distribution	9000 (1)	7000–11,000	9000 (2)	7000–11,000	0	(3000)–3000
Training	**42,000 (7)**	**18,000–69,000**	**34,000 (7)**	**15,000–54,000**	**8000**	**(24,000)–41,000**
Community sensitisation	**81,000 (13)**	**66,000–96,000**	**96,000 (20)**	**80,000–112,000**	**(15,000)**	**(37,000)–7000**
Radio ad	6000 (1)	3000–10,000	6000 (1)	3000–10,000	0	(6000)–5000
Banners	43,000 (7)	36,000–50,000	54,000 (11)	45,000–63,000	(11,000)	(23,000)–0
Posters	15,000 (2)	13,000–18,000	11,000 (2)	10,000–13,000	4000	1000–7000
Flyers	17,000 (3)	15,000–18,000	24,000 (5)	22,000–26,000	(7000)	(10,000)–(5000)
Albendazole administration	**385,000 (61)**	**285,000–526,000**	**291,000 (61)**	**209,000–378,000**	**94,000**	**(35,000)–261,000**
Personnel	369,000 (59)	274,000–506,000	266,000 (56)	192,000–345,000	103,000	(17,000)–262,000
Supplies	15,000 (2)	11,000–19,000	25,000 (5)	17,000–33,000	(9000)	(18,000)–(1000)
PC monitoring and evaluation	**17,000 (3)**	**16,000–19,000**	**17,000 (4)**	**16,000–19,000**	**0**	**(1000)–1000**
PC day monitoring	16,000 (3)	15,000–17,000	16,000 (3)	15,000–17,000	0	(1000)–1000
Parasitological assessment	1000 (0)	1000–2000	1000 (0)	1000–2000	0	0–0
Total annual cost	**623,000**	**495,000–762,000**	**474,000**	**397,000–557,000**	**148,000**	**(5000)–310,000**
Total five-year cost	**3,113,000**	**2,475,000–3,810,000**	**2,368,000**	**1,983,000–2,786,000**	**740,000**	**486,000–1,019,000**
Cost per person	**0.16**	**0.13–0.20**	**0.40**	**0.34–0.47**		

Abbreviations: 95% CI: 95% credible interval (CI), i.e., the range where the results of 95% of the iterations fall. [a]Values based on the Monte Carlo simulation conducted using data obtained from the cost survey, costs in PHP adjusted to 2021 using consumer price index; and converted to $ (rate: $1 = PHP 49.28). [b]Parentheses in financial impact denote negative number or savings when MDA is implemented.

Table 3: **Financial cost of mass drug administration and expanded school-based targeted preventive chemotherapy and financial impact of implementing mass drug administration in Zamboanga Peninsula, Philippines based on Monte Carlo simulation.[a]**

Vietnam.[17] One reason for the smaller incremental cost of MDA in this study is that the expanded school-based targeted PC in Zamboanga Peninsula covered 90% more children (625 thousand compared to 1.189 million) and an additional 353 secondary schools than if only primary schoolchildren were targeted for PC in the region (Nieto Fernandez, Philippine Department of Health, personal communication) as in the other studies,[16,17] thereby increasing costs. In addition, there were savings in community sensitisation ($15,000) for MDA when compared to expanded school-based targeted PC ($81,000 vs $96,000) due to more efficient use of information, education, and communication materials if deployed in the communities. The higher total annual economic and financial costs for MDA is driven mostly by more albendazole and more personnel required to administer albendazole.

The 29% incremental cost of MDA over expanded school-based targeted PC is also much lower compared to the percentage increase in the population targeted (317%) between the two strategies, suggesting the potential benefit of implementing MDA. While this does not imply the cost-effectiveness of MDA, it does suggest that it is worth investigating as a potential strategy for attaining targets for STH control through a cost-effectiveness analysis.

The financial impact to the national or local governments of implementing MDA in the region in lieu of the expanded school-based targeted PC ($148,000) represents 0.2% of the budget of the regional Department of Health in 2023 (PHP 3.3 billion or $67.3 million).[39]

In our study, the cost per person at-risk for expanded school-based targeted PC ($0.57) was 2.6 times higher than that for MDA ($0.22), whereas the cost per person treated for school-based targeted PC was just under two times more than the per person cost for MDA in Vietnam, Benin, India, and Malawi, albeit these studies have calculated the cost per person treated which makes direct comparison challenging.[16,17] In our study, we estimated the cost per person at risk because preventive chemotherapy and other public health interventions are planned for at-risk populations, including the resources needed to implement the intervention. For instance, the drugs (anthelmintics), the personnel (e.g., health workers), and consumables (e.g., IEC materials) are planned based on the population at risk/targeted population. Thus, our results would be relevant for decision-making. This approach is not uncommon, even for NTD control interventions.[40] The cost per person targeted demonstrated that the increased costs are low relative to the increased size of the target population. This, however, should not be over-interpreted due to various limitations, including the difference in the uptake of either MDA or expanded school-based targeted PC and the STH infection prevalence in the two population groups. Assuming a 92.60% coverage[41] in 2022 would result in a cost per person treated for MDA at $0.23, a marginal increase from the cost per person targeted at $0.22. Meanwhile, assuming a 42.06% coverage[41] in 2022 for school-based targeted PC would result in a cost per person treated for expanded school-based targeted PC at $1.25, a considerable increase from the $0.57 cost per person targeted. Of note is that due to a devolved health system, challenges with information systems, and reorganization in the Department of Health Disease Prevention and Control Bureau where there is lack of clarity on the responsible people per program, the coverage data used in this study and reported to WHO may not be accurate or complete.

The lower cost per person targeted or treated for MDA compared to expanded school-based targeted is likely due to economies of scale,[32] with MDA targeting more than three times the population covered by the expanded school-based targeted PC, but with the cost of personnel for albendazole administration not increasing at the same rate. The same costs are incurred in both strategies for PC monitoring and evaluation while even having savings in community sensitization.

A cost-effectiveness analysis, potentially using our cost survey results, would be useful in evaluating the trade-off between the cost and benefits of MDA compared to the expanded school-based targeted PC. However, we were unable to conduct such an analysis due to the lack of data on the effectiveness of MDA and expanded school-based targeted PC in reducing the prevalence and intensity of STH infections. As opposed to our cost analysis where examining the cost per person targeted would suffice, a cost-effectiveness analysis would require examining the cost per person treated because less treated people will translate to less effectiveness of the intervention.

Additional limitations include the following. We assumed that the albendazole tablets were purchased by the government and not donated through WHO, as there had been years when the Philippines paid for albendazole. Nonetheless, this should have minimal effect on the results considering that the purchase price of albendazole was only a small proportion of total cost (11% for MDA and 4% for the expanded school-based targeted PC). Another limitation is that only one region was included in the analysis, and therefore could not estimate national costs. The heterogeneity among various cost studies made it difficult to compare cost estimates. Of note is that we did not compare the cost per person we obtained in our study with the cost per person obtained in other studies. We only compared the pattern between the two strategies in our study and with other studies. There were also differences in cost categories used in various cost studies. For instance, the Deworm3 study included supportive cost, which was the cost of additional activities needed to increase coverage.[16] Lastly, this study's budget impact analysis component did not consider the cost-offset of the potential decrease in STH infections due to the lack of data on effectiveness.

By investing resources for expanded school-based targeted PC, the Philippines went beyond the WHO recommendation, in an attempt to address the ongoing STH burden after 10 years of primary-school only targeted PC.[3] There is evidence however, that STH burden remains high despite years of expanded school-based targeted PC implementation, with prevalence of moderate-to-heavy intensity *A. lumbricoides* and *T. trichiura* infections in the general population as high as 11% and 10% (Winston Palasi, Philippine Department of Health, personal communication). Indeed, a systematic review and meta-analysis found that since nationwide PC for STH control was implemented, STH prevalence and intensity reduction were only observed in children.[22] Therefore, it should be examined if these resources would be better invested for implementing MDA, particularly given our findings that switching to MDA corresponds to a 31% incremental financial cost representing 0.2% of the regional Department of Health budget and much lower cost per person at-risk for MDA.

Contributors

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Data sharing statement

The data analyzed in this study are provided in the article or supplementary materials. Further inquiries should be directed to the corresponding author.

Editor note

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Declaration of interests

The authors declare no competing interest.

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Appendix A. Supplementary data

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