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A cost analysis of options for schistosomiasis control MDA programs targeting children aged five years and below in uMkhanyakude District of KwaZulu-Natal Province, South

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Abstract

Background Schistosomiasis negatively impacts early childhood development. Inclusion of children aged five years and below in mass drug administration (MDA) programs for controlling schistosomiasis could improve early childhood development in communities where the disease is endemic. We estimated the projected cost of implementing a schistosomiasis control MDA program for children aged five years and below in the uMkhanyakude district of South Africa.

Method We calculated the cost of implementing a schistosomiasis MDA program targeting children aged five years and below using an economies of scaled based cost function. We further compared different labor composition simulations to determine the most affordable and available human resources to implement the program. We also explored programs to which the MDA program could be integrated; and estimated what the costs for would be. Moreover, we simulated cost-effectiveness and determined the cost drivers for each simulation considered.

Results A ward-based outreach team (WBOT) for implementing a schistosomiasis MDA program targeting children 5 years old and below was the best labor composition option. The simulations conducted indicated that treating children in batches of 2500 using the WBOT team approach could reduce the cost of treatment by 53% compared to treating the children on batches of 500. Integrating a schistosomiasis MDA targeting children aged 5 years and below with the immunization program was estimated to cost 3% less than integration with the deworming and Vitamin A supplementation program indicating that the former option is more cost-effective. Praziquantel, the drug that is used to treat schistosomiasis contributed over 30% of the total cost for the program.

Conclusion. We estimated that between US$6,5 million and US$ 7,5 million would be needed to implement a cost effective MDA program targeting children 5 years old and blow over 3 years in uMkhanyakude district.

Contributions To The Literature

- This study showed how economies of scale and economies of scope impact the cost of implementing schistosomiasis control mass drug administration programs.
- We also found that it is more cost-effective to integrate a schistosomiasis control mass drug administration program targeting children aged five years and below with a mobile clinic based programs than with the clinic based immunisation program.
- We showed that the cost of branded praziquantel is a major cost driver of implementing a schistosomiasis control MDA program where generic forms of praziquantel are prohibited.

Introduction

Schistosomiasis remains prevalent in many countries especially in those economically disadvantaged[1, 2]. Globally, several initiatives and programs have been implemented to control the disease but the debate on the costing of such programs remain inconclusive [1, 3]. In a quest to promote health for all, the United Nations General Assembly adopted Agenda 2030 with seventeen Sustainable Development Goals (SDGs) in September 2015. Goal three of the SDGs seeks to promote health for all people of all ages[4]. Scholars and practitioners have since identified several diseases that need to be targeted to fulfil SDG3; one of them schistosomiasis which is widely prevalent in economically disadvantaged communities[5]. The cost of schistosomiasis treatment can be prohibitive to the affected communities[6]., contributes significantly to the accessibility of schistosomiasis control interventions to the community [7]. Schistosomiasis and the other neglected tropical diseases (NTDs) require funds for control and prevention programs in order to reach the target populations[8, 9].

The source of funding for schistosomiasis control is often external to the communities that are affected. Most of the funds for the controlling schistosomiasis and the other neglected tropical diseases (NTDs) comes from the governments of the United States of America and the United Kingdom[10]. A significant portion of funds for NTDs is provided by philanthropic organizations such as the Bill and Melinda Gates Foundation, END FUND[10] and the Schistosomiasis Control Initiative (SCI). Further support for schistosomiasis control has been provided by the pharmaceutical industry through a WHO initiative to mobilize the donation of praziquantel (PZQ). PQZ is the only WHO approved drug for treating schistosomiasis. The cost of schistosomiasis control can be significant but varies by region. For instance, in Egypt it cost US$10 million annually[11] and the country successfully controlled the disease using domestic funds[11]. Although philanthropic organizations have taken a keen interest in financing of schistosomiasis, the World Bank recommends local financing as the best option for sustainable control of schistosomiasis[12].

Much emphasis has been placed on Schistosomiasis treatment as not treating infected children negatively impacts early childhood development. This is of great concern to multilateral organizations such as the World Bank which recommends countries to invest in early childhood development programs for poverty alleviation and diminishing the probability of acquiring disease at an early age[13]. One such investment is the PZQ mass drug administration for schistosomiasis as preventive treatment in children aged five years and below[14]. Schistosomiasis is endemic in six provinces of (Limpopo, North West, Mpumalanga, Eastern Cape, KwaZulu-Natal, Gauteng) South Africa. In the uMkhanyakude district of KwaZulu-Natal and other economically disadvantaged communities, schistosomiasis is widespread and as such, children below the age of five need schistosomiasis preventive treatment [14, 15].

Community-wide treatment has been found to be the most cost-effective strategy to control schistosomiasis[16]. To align schistosomiasis control chemotherapy with the WHO strategy for global schistosomiasis control, the inclusion of children aged five years and below is paramount [17, 18]. The actual cost for schistosomiasis control mass drug administration (MDA) programs is difficult to infer from literature because of the variation in methods and cost lines used in the studies. Furthermore, it is only in 2014 that a working group to provide recommendations on the inclusion of children aged five years and below in schistosomiasis control preventive chemotherapy programs as part of the Integrated Management of Childhood Illnesses (IMCI)[19]. Thus, there is dearth in the discourse of implementing a schistosomiasis control MDA for children aged 5 years and below.

The South African government, through the National Department of Health, plans to implement a nationwide schistosomiasis control MDA program to control and eliminate the disease [20]. To support this government initiative, we therefore sought to carry out an analysis of the cost of implementing a schistosomiasis control MDA program for children five years old and below. We conducted the study in uMkhanyakude district, KwaZulu-Natal province where the disease is widespread. The uMkhanyakude district has five sub-districts. Each of the sub-districts has an average of 15 000 children aged five years and below[21]. Our analysis considered the economies of scale and economies of scope associated with the mass treatment program. This paper, therefore, is intended to inform policymakers on the budgetary requirements for designing and implementing a schistosomiasis control MDA program for children aged five years and below in uMkhanyakude district.

Methods

Site selection and study design

uMkhanyakude district was purposively selected because it is one of the districts where schistosomiasis is endemic in South Africa[22, 23]. The child health program in uMkhanyakude district is implemented through the district Department of Health[24]. The cost analysis was done from a government perspective to establish the cost that the healthcare system in the district would bear in implementing a schistosomiasis control MDA program for children aged five years and below. The data was collected between August and November 2019. All South African rand (ZAR) values were converted to

United States Dollars (US$) for ease of reference and international comparability. In this regard, the data point exchange rate as at 30 November 2019 was US$1:ZAR14.1 [25, 26].

Cost Classifications

The costs of implementing the schistosomiasis program were classified into two broad categories; fixed and variable costs. Fixed costs are those that remain constant despite changes in the number of children treated in the MDA program. Variable costs on the other hand, change with the number of children treated in the MDA program. The cost of clinic infrastructure was treated as sunk costs and hence were regarded as irrelevant for decision-making. Cost of training was also excluded from the costing exercise mainly because training for the MDA program would be done alongside IMCI training thus making it an indirect cost. Consequently, only direct costs to the treatment program were included in the costing exercise for this study. Table 1 shows the classification of costs for the MDA program.

Table 1: Classification of costs for the schistosomiasis control MDA programs

Fixed Costs	Source	Variable costs	Source
Computers	online sources	**Food**	personal communication
Laboratory Tests	National Health Laboratory Services (NHLS)	**Dose Syringe**	online sources
Labour	Department of Public Service Administration	**Office resources**	online sources
Mobile clinic (running costs)	Right2Care[27]	**Praziquantel (PZQ)**	uMkhanyakude Department of Health
Pestle and Mortar	online sources		
Weight scales	online sources		

Data Analysis

All calculations were done on Microsoft Excel Spreadsheet. The average cost of treatment per child was calculated by dividing the sum of the fixed cost and the variable costs (aggregate) by the total number of children treated. Subsequently, differential costing was determined by subtracting the average cost per child or total cost of treatment in a specific treatment of scenario from an alternative scenario.

Economies of scale were calculated by determining the difference between the average cost of treating children when the only variable in the treatment scenario is the number of children treated. Economies of scope were calculated by dividing the fixed costs with the number of programs that shared resources; adding the variable costs that were specific to the number of children treated in the MDA program and comparing that to a scenario where the MDA program was not integrated with any other program.

The total cost was calculated based on the number of children where the economies of scale were highest. Cost-effectiveness was calculated based on the average cost of treating an additional child to achieve the 75% treatment coverage that is recommended by the WHO[28, 29]. The cost proportions were calculated by comparing the contributions of each cost line to the total cost of treating 75% of the children aged five years and below in uMkhanyakude district. We used the cost of branded praziquantel in our cost analysis, therefore, cost sensitivity analysis was calculated based on the cost of using generic praziquantel and on a scenario that praziquantel was donated to the country. We used generic praziquantel as the recommended treatment to lower the cost of schistosomiasis treatment in South Africa. The donated praziquantel was used in the sensitivity determination because WHO is encouraging pharmaceutical companies to donate praziquantel to communities that need to implement schistosomiasis control mass drug administration programs[19].

Ethical Clearance

Ethical clearance was granted by the University of KwaZulu-Natal Biomedical Research Ethics Committee (reference number: BE403/18) and the KwaZulu-Natal Department of Health Research Committee (reference number NHRD_201809_007).

Results

Resource Planning and Economies of scale

Community healthcare programs in uMkhanyakude are often implemented or supported by ward-based outreach teams (WBOTs)[24]. A WBOT consists of a professional nurse, a staff nurse and community care givers (CCGs)[24]. If the simulation treatment team consists of the ward-based outreach team (WBOT) and one pediatric specialist, the average cost, per child, of treating 500 children in a schistosomiasis control MDA program for children aged below five years in uMkhanyakude District would be estimated to be US$60. If the model treatment team consists of a Medical Officer and WBOT the estimated average cost per child treating 500 children drops to US$57 indicating a decline of 5%. However, a WBOT only model treatment team requires US$27 which is 20% less per child compared to when a pediatrician is part of the treatment team. In the simulation, if the number of children treated increased to 2500, the average cost per child reduced to US$30 (51% drop) when a pediatrician is part of the treatment team; reduced by 49% when a medical officer is part of the treatment team instead of a pediatrician; and by 53% when the treatment team is the WBOT. If the number of children is increased to 18 500, the average cost of treatment per child reduces by 42% from US$60 to US$23, by 62% for a pediatrician led team, by 52% for a Medical Officer led team and 53% for a WBOT only treatment team. Table 2 shows the project's simulated economies of scale.

Table 2: Total Cost Over A 3-year Period

	A	B	C
Year 1	2 430 282	1 632 496	2 048 131
Year 2	2551796,387	1714121,131	2150537,323
Year 3	2679386	1799827,188	2258064,19
Total	7 661 465	5 146 445	6 456 732

Key:

A	Integration with immunisation program at current 85% coverage
B	Integration with the deworming and Vitamin A supplementation program at current 74 % coverage
C	Integration with the deworming and Vitamin A supplementation program at assumed improved 85 % coverage

If only the WBOT is used to treat 2500 children, and laboratory diagnosis is limited to a sample of 500 children, the average cost of treatment per child in the MDA program is 18% lower than when all the children are screened and treated for schistosomiasis. If 18 500 children are treated by a WBOT based on results of testing 500 samples, the cost of the MDA program would be 26% lower than when all the children are tested. A scenario in which only a sample of 500 children was tested for schistosomiasis using laboratory methods was used for further calculations. Figure 1 depicts economies of scale for each treatment model.

As shown in Fig. 1, the average cost per child in a schistosomiasis control MDA program decreases sharply when the number of children treated are increased from less than 500 children to about 2500 children. A gradual decrease in the cost of treatment per child was observed if the number of children to be treated was increased to more than 2500.

Implementation strategy and economies of scope.

uMkhanyakude district has fixed clinics and School Health Mobile Clinics where the vaccination program is done. In comparing the cost of using the fixed clinics and mobile clinics, we assumed that four additional community caregivers would be required in the mobile clinics to make up for the absence of the parents at the schools when the School Health Mobile Clinic is used in crèches and early childhood development centers. It cost 14% more per child to treat the children in the School Health Mobile Clinic than it would cost in the fixed clinics when 500 children were treated. If 2500 children are treated, it costs 6% more to treat children in the School Health Mobile Clinic compared to the fixed clinic. Figure 2 shows the economies of scope for the program based on simulations.

Currently, the vaccination program in uMkhanyakude District is done in the fixed clinics while the school health mobile clinics are used for the deworming program. The deworming program is integrated with the vitamin A supplementation program. If the schistosomiasis control MDA is in integrated with the vaccination program, it costs 33% less to treat 500 than it would to treat 500 children if the MDA is implemented independently in a fixed clinic. This cost difference reduces to 14% when 2 500 are treated. If the schistosomiasis control program is integrated with the deworming and vitamin A supplementation program, the cost of treating 500 children becomes 47% lower than treating the children in an independent schistosomiasis control MDA program using a mobile clinic. The cost difference reduces to 22% when 2 500 children are treated.

If the schistosomiasis control MDA for children aged five years and below is integrated to the fixed clinic, it costs 9% more to treat 500 children than when the MDA program is integrated with the deworming and vitamin A supplementation program. The cost difference reduced to 3% when 2 500 were treated. There was no difference in the cost of using either of the options to treat at 17 000 or more.

Total Costs and Cost Effectiveness Analysis

The number of children that could be treated in the clinic based immunization program was 70 515 and averaged 25 children per day assuming that the program was rolled out in all 52 clinics and that each month had 21,67 working days. The number of children that could treated in the school based deworming and vitamin A supplementation program was 56 154 and averaged 45 children per day assuming that each sub-district was given 4 mobile clinics and that each month had 21 working days.

The total cost of treating children in the fixed clinic based program was US$2 430 282 and that of treating the children in the school/mobile clinic based program was US$1 632 496. When the coverage of the school/mobile clinic based program was equal to that of the fixed clinic based program the total cost of the MDA program was US$2 048 13. The total amount of money required over a three-year period when the coverage of both the fixed clinic based program and the school/mobile clinic based program were equal at 85% was US$7 661 465 for the fixed clinic based program and US$6 456 732 for the school/mobile clinic based program when a discount rate of 5% per annum was used (Table 3).

Table 3: Total cost and cost effectiveness analysis

			Population		
	Population	WHO	A	B	C
DSL	75986	56990	70515	56 154	70 515
SDL	15197	11398	14103	11 231	14103
			Cost of Treatment (US$)		
DSL			2 430 282	1 632 496	2 048 131
SDL			372 853	325 031	408 157
Cost Effectiveness = Cost per additional child relative to WHO recommendation.					
			180	1953	151

Key:

A	Integration with immunisation program at current 85% coverage
B	Integration with the deworming and Vitamin A supplementation program at current 74 % coverage
C	Integration with the deworming and Vitamin A supplementation program at assumed improved 85 % coverage

The cost-effectiveness of each MDA implementation option was calculated based on the cost of treating an additional child beyond or to reach a 75% treatment coverage. When using the fixed clinic based program, each child that was added to exceed the 75% treatment coverage target cost US$180. When using the school/mobile clinic based program US$1 953 was required per additional child to attain the 75% treatment coverage threshold. When the coverage of the clinic based program and that of the school/mobile clinic based program were equal at 85%, each child that was added to the school/mobile clinic based program cost US$151.

Cost Drivers

PZQ was the main cost driver of the MDA program and accounted for 30 % of the costs of the schistosomiasis control MDA program for children aged five years and below when either the fixed clinics or mobile clinics were used. Dose syringes contributed 12 % of the costs of the fixed clinic based program costs and 15 % of the school/mobile clinic based costs. Table 3 below. The cost of labor accounted for 24% of the fixed clinic based costs and 3% of the school/mobile clinic based costs. The main cost drivers of the program are shown in Table 4.

Table 4: Cost Drivers

Cost Drivers				
		A	**B**	**C**
Cost line	**Cost per unit**	**% Total cost**	**% Total cost**	**% Total cost**
PZQ	9,56	27,74	32,88	32,91
Dose Syringe	4,25	12,34	14,63	14,64
Food	2,13	9,19	7,31	7,32
Labour	11 098,34	23,75	3,40	2,7

Key:

A	Integration with immunisation program at current 85% coverage
B	Integration with the deworming and Vitamin A supplementation program at current 74 % coverage
C	Integration with the deworming and Vitamin A supplementation program at assumed improved 85 % coverage

Sensitivity Analysis

The main cost driver of the treatment program was the cost of PZQ. The sensitivity of the total costs to the use of generic drugs is detailed in Table 5:

Table 5: Sensitivity Analysis

Option	A	B	C
Total Cost of Treatment	2 430 282,27	1 632 496,32	2 048 130,78
Cost of PZQ	674 056,44	536 775,55	674 056,44
Cost of Low-end Generics	262 882,01	209 342,47	262 882,01
Cost of Middle Cost Generics	303 325,40	241 549,00	303 325,40
Cost of High end generic	404 433,87	322 065,33	404 433,87
MDA Cost Reduction Donated PZQ (%)	27,74	32,88	32,91
MDA Cost Reduction Low-end generic (%)	16,92	20,06	20,08
MDA Cost Reduction medium cost generic (%)	15,25	18,08	18,10
MDA Cost Reduction High End generic (%)	11,09	13,15	13,16

Key:

A	Integration with immunisation program at current 85% coverage
B	Integration with the deworming and Vitamin A supplementation program at current 74 % coverage
C	Integration with deworming and Vitamin A supplementation program at assumed improved 85 % coverage

The financial cost of the MDA program reduced by 30% across all options when PZQ was donated. When a low end generic form of PZQ was used the total cost of the MDA program reduced by 20%. When high end PZQ was used the cost of the MDA program reduced by 10% for the fixed clinic based program and by 15% for the school/mobile clinic based program.

Discussion

Resource planning

The Essential Medicines List of South Africa stipulates that a pediatric specialist should be involved in the treatment with praziquantel of children aged below five years[30]. South Africa is currently experiencing a shortage of specialist skills across all fields of medicine[31]. Rural areas such as uMkhanyakude District are the most affected by the shortage of medical professionals such as pediatric specialists[32]. General practitioners are also inadequate to service the public health needs of South Africa's rural districts including the uMkhanyakude district. As a result, many of the healthcare programs are managed by WBOTs[24]. The inclusion of participation of a pediatrician in the schistosomiasis control MDA program for children aged five years and below was found to be the most expensive option in the human resources planning choices that are available. Treatment done using a WBOT only is the most affordable and practical option for a schistosomiasis control MDA program for children aged five years and below.

Economies of scale.

The cost of treating children aged 5 years and below with PZQ in a schistosomiasis control MDA program decreases with an increase in the number of children treated. This decrease in costs is a consequence of economies of scale[33, 34]. Economies of scale occur because the fixed programmatic costs such as computers, weight scales and labor remain constant even when the number of children increases[33, 35]. The economies of scale increase exponentially until the increasing variable costs are significant enough to buffer the reduction in the average cost of treatment per child that occurs as result of the fixed costs. uMkhanyakude district has five sub-districts. Each of the sub-districts has an average of 15 000 children that are aged five years and below. Our findings indicate that economies of scale will exist when the MDA program is implemented at sub-district level (population: 15 000). In practice, the economies of scale will only exist

up to a specific threshold beyond which diseconomies of scale will cause the average of cost of treating a child in the MDA program will increase[16, 36].

Diseconomies of scale occur when the increase in variable costs due to an increase in the number of children being treated outweighs the reduction in the average cost per child that results from the fixed costs remaining constant when the number of children that are treated increases[34]. When diseconomies of scale are experienced operational strategies to reduce costs reduce upscaling costs[34]. A point at which economies of scale reduce significantly was identified as 2500 children receiving treatment under the program. We recommend that each schistosomiasis control treatment station in uMkhanyakude district should target about 2500 children to be cost effective.

Economies of scope

The WHO recommends that schistosomiasis control MDA be integrated with existing child health activities[37]. Healthcare program integration improves the financial sustainability and operational efficiency that is needed by NTDs control programs[38]. In uMkhanyakude district, the immunization program and the deworming and vitamin A supplementation programs could be used to implement the schistosomiasis control MDA program for children aged five years and below[24]. When programs are integrated, some of the common costs are shared between more than one program, thus creating economies of scope[34]. Resource planning is essential in the exploitation of economies of scope because the economies of scope will increase when the biggest cost drivers of individual programs are the same in the programs that are being integrated[39].

Cost drivers

The biggest cost driver of the MDA program was the cost of praziquantel, which contributed 59% of the total cost of the MDA program in the model used in this study. In South Africa, only branded PZQ is licensed for use. The cost of PZQ in South Africa is 50 times more that the WHO expected cost[40]. The licensing of generic PZQ could make a significant contribution to the control of schistosomiasis in South Africa and in lowering the cost of schistosomiasis control MDA programs in the country. In Canada the use of generics reduces the cost of drugs by an average of 88%[41]. In South Africa, the difference in cost of drugs (brand to generic) was found to average 39%; 45% and 60% for the high cost; medium cost and low cost drugs respectively[42]. We used these parameters in our sensitivity analysis and found that the use of generic PZQ could lower the total cost of the MDA program by between 10% and 20%. Donated PZQ could reduce the cost of a schistosomiasis control MDA program for children aged five years old and below in the uMkhanyakude district by about 30%.

The second largest cost driver was the dose syringes. The dose syringes could be replaced by spoons provided strict infection prevention control protocols are followed. The use of spoons has been successful in clinical studies[18]. Food also contributed significantly to the cost of the MDA program. Food is important in the MDA program to improve the systemic assimilation of PZQ and to ameliorate some of the side effects of PZQ. Schistosomiasis affects poor communities; hence it is expected that most of the children affected by schistosomiasis will have inadequate access to food. Food is therefore an integral part of the treatment process. In instances where feeding schemes are part of the crèches and early childhood development programs, 10% of the total cost of treatment could be removed by treating the children immediately after mealtime. Cost driver reduction measures are more effective when they add value to an already cost-effective program.

Total cost and Cost-effectiveness analysis

The cost effectiveness of PZQ MDA programs in the control of schistosomiasis is understood and well document[43]. We considered programmatic cost-effectiveness in our study to determine the best programmatic strategy that could be used to implement a schistosomiasis control MDA program for children aged five years and below in uMkhanyakude. Based on the existing coverage (85%) of the fixed clinic immunization[21], it is estimated that US$100 per child would be required to achieve the WHO recommended 75% coverage when the MDA program is integrated with the immunization program.

When the MDA program is integrated with the mobile clinic deworming and vitamin A supplementation whose coverage is 74%, US$1953 would be required to close the 1% coverage gap towards the WHO recommended coverage. Based on the cost per additional child only, the immunization program is a more cost-effective approach. However, on assumption that the coverage of the MDA programs is the same at 85% the deworming and vitamin A supplementation program is a more cost-effective vehicle for the schistosomiasis control MDA program for children aged five years and below. The deworming and Vitamin A supplementation program from 46% in 2017 to 74% in 2019[21, 44]. This increase in coverage shows that economic determination of program integration choices requires predictive analysis of program performance when costs are projected. The use of cost functions that could resolve economies of scale and economies of scope illustrates the complexity of the economic evaluations that are required to inform program integration. In addition to economic evaluations, policy and political decisions may influence the decision making process.

Strengths and weaknesses of the study

The strengths of this study is premised on the fact that it took into account the economies of scale and economies of scope to determine the cost of implementing a schistosomiasis control MDA program for children aged five years and below. The study therefore aligns to the programmatic decision making process that is involved in implementing PZQ MDA programs. In addition, the processes that govern healthcare interventions in South Africa is similar throughout the country making the study applicable to several districts in South Africa where schistosomiasis is endemic. The findings of this study also account for the recommended improvement in schistosomiasis treatment coverage to 85%[1]. The limitation of the study is that some of the initial costs such as community healthcare worker training were not considered in this study as this information was not readily available.

Conclusion

The planned schistosomiasis control MDA program for school going children in South Africa could be expanded to include children aged five years and below in the districts where schistosomiasis is endemic. Implementing a schistosomiasis control MDA program for children aged five years and below in uMkhanyakude district can be done by a WBOT. Such an MDA program could be integrated with either the immunization program or the deworming and Vitamin A supplementation program. Using a discount rate of 5%, a 3-year budget for a schistosomiasis control MDA program for children aged five years and below in uMkhanyakude would require between US$6,5 million and US$ 7,5 million in the next three years. Cost cutting measures for the implementation of the MDA program could include using generic or donated PZQ.

Abbreviations

CCG: Community Care Giver

DoH: The South Africa Department of Health

ECD: Early Childhood Development

MDA: Mass Drug Administration

NHLS: National Health Laboratory Services

NTD: Neglected Tropical Diseases

PZQ: Praziquantel

SCI: Schistosomiasis Control Initiative

SDG: Strategic Development Goal

STH: Soil Transmitted Helminths

TB: Tuberculosis

UKZN: University of KwaZulu-Natal

WBOT: Ward Based Outreach Teams

WHO: World Health Organisation

ZAR: South African Rand

Declarations

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Availability of data and materials

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Authors' contributions

MVN conceived the study in collaboration with MC. Both authors were involved in data analysis and interpretation of results. Both authors revised and approved the final manuscript.

Consent for publication

Not applicable.

Competing interests

The authors declare no that they have no competing interests.

Ethics approval and consent to participate

Ethical clearance was obtained from the University of KwaZulu-Natal Biomedical Research Ethics Committee (reference number: BE403/18) and the KwaZulu-Natal Department of Health Research Committee (reference number

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Figures

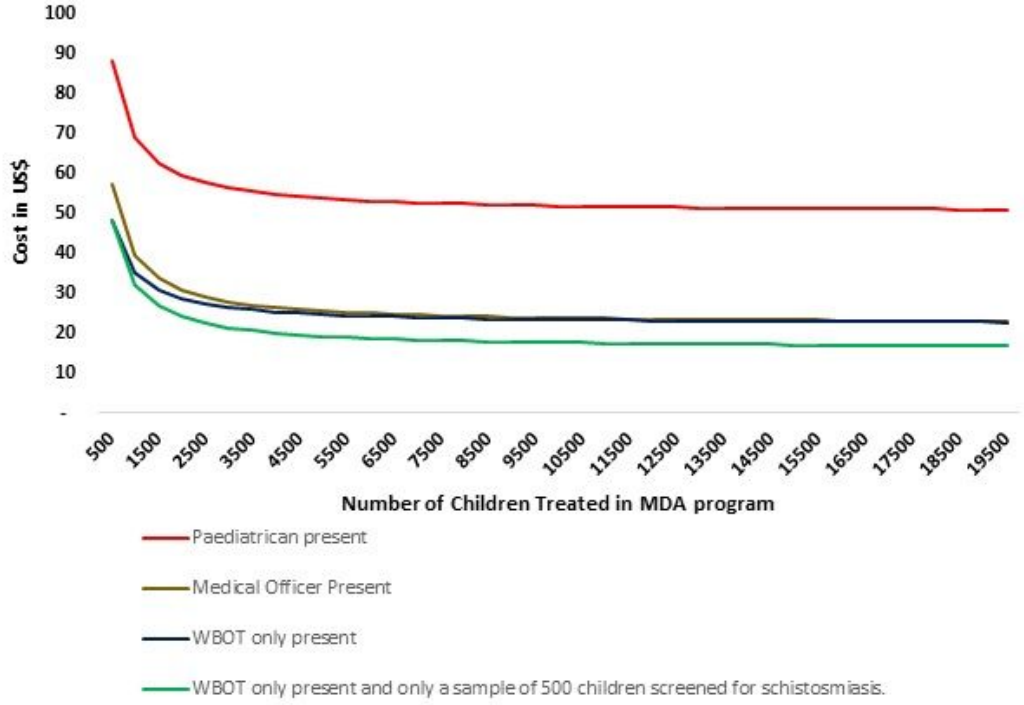
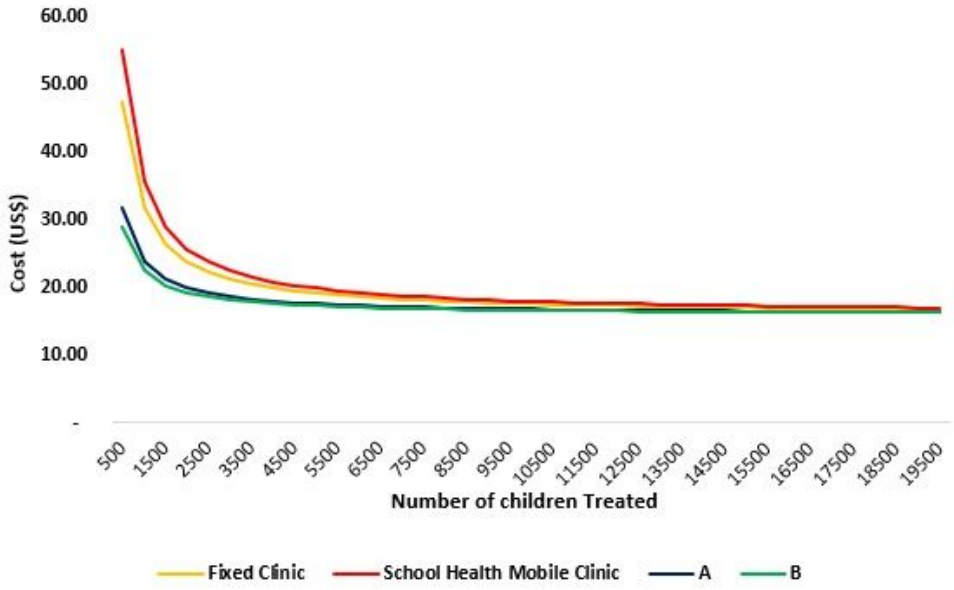


Figure 1

Economies of scale per treatment model



Key:
A: Schistosomiasis control MDA program integrated with vaccination program in a fixed clinic.
B: Schistosomiasis control MDA program integrated with deworming and vitamin A

Figure 2

Economies of Scope of the treatment program

Supplementary Files

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