COST-BENEFIT ANALYSIS OF COMMUNITY HEALTH WORKER LED SCREENING AND TREATMENT FOR HYPERTENSION IN GHANA

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Cost-benefit analysis of community health worker led screening and treatment for hypertension in Ghana

Ghana Priorities

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Academic Abstract

Hypertension-related diseases are the most rapidly growing causes of death and morbidity over the last decade in Ghana. At the same time, Ghana's current health profile is still dominated by diseases such as diarrhea, malaria and neonatal disease. The paper conducts a cost-benefit analysis of a community health worker led hypertension mass screening and treatment strategy in Ghana to assist policy makers in determining to what extent marginal resources should be allocated towards a particular hypertension-control strategy. Our analysis shows that for every 25,000 people above the age of 30 screened, a treatment regime of diuretics and 30 percent adherence in the long run is expected to avoid 29 deaths (505 life years), 11.1 cases of heart disease, 0.1 cases of stroke and 1.6 heart failures over ten years. These benefits are worth GH¢ 7.1 million (1.6 million USD) at an 8 percent discount rate. The costs of the intervention are GH¢ 2.2 million (0.5 million USD), resulting in an overall benefit-cost-ratio (BCR) of 3.3. This result is most sensitive to the costs of case management. While screening and treatment is an effective use of resources, insofar as benefits exceed costs, other interventions to address malaria, nutrition, maternal and child health in Ghana are likely to yield higher BCRs.

Key Words: Cost-benefit analysis, Ghana, hypertension, screening, treatment, cost-effectiveness, blood pressure

Policy Abstract

Key Takeaways

- Screening 25,000 individuals above the age of 30 for hypertension, and treating individuals with diuretics will lead to 29 deaths avoided, 11.1 cases of heart disease, 0.1 cases of stroke and 1.6 heart failures avoided over ten years assuming 30% long term adherence to treatment. These benefits are worth 7.1m GH¢ over ten years.
- The cost of the intervention are 2.2m GH¢ over ten years with two thirds coming from case management. The intervention would be less expensive if community health workers could be used instead of relatively more costly physicians.
- Screening and treatment is an effective use of resources in that benefits exceed costs by 3.3. However, other interventions in malaria, nutrition and maternal and child health are likely to yield larger benefits per unit cost. Ghana should revisit this finding when the prevalence of hypertension is larger.

The Problem

In recent years, Ghana, like many other developing countries has been going through an epidemiologic transition where the proportion of deaths from non-communicable diseases is rapidly increasing, particularly cardiovascular related diseases, cancers and diabetes (IHME, 2019).[1] The number of persons in the population with hypertension appears to be increasing year-on-year and has become the most rapidly growing concern of the top 10 disease causes over the last decade in Ghana as further evidenced by the Ghana Health Service Facts and Figures since 2005 (GHS, 2018).

Estimates of prevalence of hypertension (systolic blood pressure of at least 140 mmHg or a diastolic blood pressure of at least 90 mmHg) is around 13 percent among men and women aged 15-49 as per the 2014 Ghanaian Demographic and Health Survey (GHDS) (Ghana

[1]This is in part due to the aging population. However, aging in Africa is not a big driver as falling child mortality rate.

Statistical Service et al. 2015). Hypertension is significantly more prevalent in urban compared to rural areas.

As part of efforts to improve detection, treatment and control of hypertension, the Ghana Health Service (GHS) together with other health Agencies of the Ministry of Health (MoH) and its development partners are piloting a few innovative strategies in some parts of the country. For example, there is the community-based hypertension management project (ComHIP) which was launched in 2015 and is being implemented in the Lower Manya Krobo municipality and seeks to bring hypertension services closer to the community by introducing blood pressure screening points in the places where people live, work and shop (Adler et al, 2019). This has been done through diverse multi-sector partnerships, for example by enabling certain local shops to offer screening (Adler et al, 2019). The Ghana health authorities are working towards scaling the program to additional regions and integrating the ComHIP training curriculum and treatment guidelines into the national system and has the potential to avoid significant mortality and morbidity if replicated in other parts of the country and for other non-communicable diseases (Adler et al, 2019).

Intervention: Community health worker led screening and treatment for hypertension

Overview

The intervention envisages a cadre of community health workers visiting households to screen individuals for hypertension and other cardiovascular disease risk factors. We limit the target group to those aged 30 and above since the prevalence of hypertension is relatively low at younger ages. Individuals who are assessed as having high blood pressure are referred onto a health facility for further assessment and, if deemed necessary by the medical practitioner, placed on medication.

Following the recommendations of Chalkidou, Lord and Gad (2017), we envisage that individuals are placed on diuretics in the first instance.[2] In line with recent developments

[2] The 2017 Standard Treatment Guidleines for Ghana recommend diuretics as one of the preferable choices and is the reason it is recommended as an intervention in this study (see STG, 2017). Consultations with experts in the Ghana Health Service, however revealed that calcium channel blockers are preferable by practioners in Ghana

towards increased task shifting and demonstrated ability of nurses to successfully manage hypertension (Ogedegbe et al, 2018), we assume community health workers predominantly manage those with mild or moderate hypertension while physicians manage those with severe hypertension.

Implementation Considerations

The analysis follows a single cohort of 12,500 men and 12,500 women who are screened in the initial year of the intervention (2018). This population size is set to approximate the average number of individuals in the target population (30 years and older) in a representative district in Ghana. The cohort is assumed to be representative of the wider population in the target age group.

Our analysis stratifies the target population into five age sub-groups (10-year increments between 30 and 69 plus one age group for all those over 70), two gender sub-groups (men and women) and four hypertension sub-groups (none/controlled, mild, moderate and severe). In total we have 40 sub-groups each with different age-gender-hypertension characteristics.

Costs and Benefits

Costs

There are two broad categories of costs – the one-off costs of screening and referral, and the ongoing costs of treatment and management.

The total costs of screening 12,500 men and 12,500 women and referring 2,536 individuals are therefore estimated at GH¢ 591,000. This cost is incurred only once at the start of the intervention timeline. This includes an estimated direct screening cost of GH¢ 330,500 for 25,000 people, an estimated time cost for 25,000 people of GH¢ 16,500 and the cost of initital referral at GH¢ 244,200 based on GH¢ 90 physician cost, GH¢ 4 for time of 1.25 hours per patient (including travel and waiting time) for 2,536 individuals – the estimated yield from screening.

The treatment costs for diuretics are drawn from Chalkidou, Lord and Gad (2017) who identify a medication cost of GH¢ 26 per person per year. In addition, costs of patient management by physicians for severe hypertension and community health workers for moderate and mild

because of patient complaints of the discomfort associated with the use if diuretics. The sensitivity analysis below addresses the alternative of using calcium channel blockers.

hypertension are included. For physician visits, we assume a direct cost of GH¢ 90 per visit and for community health worker visits we estimate a resource cost of GH¢ 17 per visit. Overall management and drug costs are approximately GH¢ 395,000 in the first year and decline to GH¢ 141,000 by year five of the intervention due to attrition.

The overall costs of the intervention are estimated at GH¢ 2.2 million, with two thirds attributable to case management, 27% to initial screening and 7% to the cost of diuretics themselves.

Benefits

Commencing treatment should lead to a reduction in blood pressure and a reduction in the risk of hypertension related morbidity and mortality. To estimate the benefits, we use a Markov model previously created for a hypertension modelling exercise in Ghana (Chalkidou, Lord and Gad, 2017).

With a treatment regime of diuretics and 30 percent adherence after five years, the intervention is expected to avoid 29 deaths (505 life years avoided), 11.1 cases of heart disease, 0.1 cases of stroke and 1.6 heart failures. While overall health of the screened population improves, it will also lead to the onset of 1.1 cases of diabetes, relative to no intervention. These benefits are worth GH¢ 7.1 million (1.6 million USD) over ten years at an 8 percent discount rate. The costs of the intervention are GH¢ 2.18 million (0.5 million USD), resulting in an overall BCR of 3.3.

BCR Summary Table

Interventions	Discount Rate	Benefit	Cost	BCR	Quality of Evidence
Community health worker led screening and treatment for hypertension	5%	7.8	2.3	3.4	Medium
	8%	7.1	2.2	3.3	
	14%	6.0	2.0	3.1	

Notes: All figures assume a 5% discount rate

1. Introduction

Historically, health policy and research in Ghana and other parts of Africa have been focused more on communicable diseases. This is not surprising given the prevalence of malaria, HIV/AIDS and diarrheal conditions in Africa. But in recent years, Ghana, like many other developing countries has been going through an epidemiologic transition where the prevalence of non-communicable diseases is rapidly increasing, particularly cardiovascular related diseases, cancers and diabetes (IHME, 2019). Among the cardiovascular diseases (CVD), ischemic heart disease is the 6th largest cause of death and disease, while high blood pressure is the 4th largest risk factor for health-related complications such as stroke, heart failure, coronary heart diseases, peripheral vascular disease, retinal hemorrhage, visual impairment, and renal impairment (IHME, 2019). The number of people suffering from hypertension appears to be increasing year-on-year and has become the most rapidly growing concern of the top disease risk factors over the last decade in Ghana as further evidenced by the Ghana Health Service Facts and Figures since 2005 (GHS, 2018).

Estimates of prevalence of hypertension (systolic blood pressure of at least 140 mmHg or a diastolic blood pressure of at least 90 mmHg) is around 13 percent among men and women aged 15-49 as per the 2014 Ghanaian Demographic and Health Survey (GDHS) (Ghana Statistical Service et al. 2015) as shown in. Hypertension is significantly more prevalent in urban compared to rural areas.

Table 1: Prevalence of Hypertension among men and women aged 15 – 49 surveyed during the 2014 Demographic and Health Survey

Age/Residence Group	**Prevalence of Hypertension % (Women)**	**Prevalence of Hypertension % (Men)**
15 - 19	1.8	2.6
20 – 24	4.6	6.3
25 – 29	7.2	11.4
30 – 34	13.7	13.1
35 – 39	17.1	21.6
40 – 44	24.8	21.2
45 – 49	38.3	24.3
Total (15-49)	12.9	12.5
Urban	15.8	15.8
Rural	9.5	8.8

Source: Ghana Statistical Service et al. 2015

Furthermore, the level of awareness and treatment status of women and men classified as hypertensive, is alarmingly low with 63 percent women and 86 percent men having high blood pressure, reported to be unaware of their condition. Amongst the hypertensive patients, only 17 percent of the women and 6 percent of the men were treated and controlled (Ghana Statistical Service et al. 2015). The 2014 GDHS Survey also looked at specific actions to lower blood pressure among respondents with a history of hypertension (see Table 2). While the efforts at medication by patients are commendable (72 percent of women and 65 percent of men were taking prescribed medication), more needs to be done on preventive aspects.

Table 2: Hypertension History and Actions Taken to Lower Hypertension

Actions Taken to Lower Blood Pressure	Women	Men
Taking Prescribed medication	71.8	64.6
Controlling or Losing Weight	51.0	68.5
Cutting Down Salt in Diet	72.8	74.6
Exercise to Control Hypertension	49.1	74.5
Cutting Down Alcohol Intake	21.3	57.3
Stopped Smoking	13.7	42.9

Source: Ghana Statistical Service et al. 2015

The growing challenge of hypertension has not gone unnoticed by policy makers in Ghana. The national policy for the prevention and control of non-communicable diseases, launched in 2012, is the blueprint that sets out the broad path and overall roadmap the country needs to pursue in its efforts to prevent, control and manage hypertension and other NCDs.[3] As part of efforts to improve detection, treatment and control of hypertension, the Ghana Health Service (GHS) together with other agencies of the Ministry of Health (MoH) and its development partners are piloting a few innovative strategies in some parts of the country. For example,

[3] The NCD policy draws inspiration from other national and international resolutions, policies and strategies including those of the World Health Organization (WHO) (GHS, 2017). The NCD policy and protocol for the treatment and management of cardiovascular diseases in Ghana follows the World Health Organization Package of Essential NCD Interventions (WHO-PEN) comprising the following four steps: 1) inquiry about the patient's history (e.g. heart attack, stroke, lifestyle behaviors, diabetes); 2) physical and laboratory experiments (including BP measurements, fasting glucose, cholesterol); 3) estimation of cardiovascular disease risk based on risk charts provided by WHO (categorized as low, medium, or high); 4) initiation of drug therapy, lifestyle counseling, and follow-up visits (Blackstone, 2017). With regards to hypertension screening, current protocols in Ghana include measuring blood pressure, providing patient counseling, and documenting patients' conditions and course of action. It is usually recommended that after two or more readings of elevated blood pressure, patients need to be referred to a physician for further assessment (Blackstone, 2017).

there is the community-based hypertension management project (ComHIP) which was launched in 2015 and is being implemented in the Lower Manya Krobo municipality which seeks to bring hypertension services closer to the community by introducing blood pressure screening points in the places where people live, work and shop (Adler et al, 2019). This has been done through diverse multi-sector partnerships, for example by enabling certain local shops to offer screening (Adler et al, 2019). The Ghana health authorities are working towards scaling the program to additional regions and integrating the ComHIP training curriculum and treatment guidelines into the national system and has the potential to avoid significant mortality and morbidity if replicated in other parts of the country and for other non-communicable diseases (Adler et al, 2019).

Blackstone (2017) cites the cluster-randomized trial of task-shifting and blood pressure control (TASSH) in community health centers and district hospitals which is also currently on-going in Ghana (Ogedegbe et al, 2018). The 'task shifting strategy' involves a rational movement of primary care duties from physician to non-physician health care workers, and would alleviate the demands on physicians. The 2018 Ghana Health Service Facts and Figures puts the doctor to population ratio at 1:7374 which is significantly lower than the WHO recommended figure of 1:1000. Task-shifting would allow other health workers to manage and treat non-complicated cases of hypertension and only refer high-risk cases to physicians.

Given this context, now is an opportune time to formally assess the costs and benefits of a strategy to address the hypertension challenge in Ghana. Like all countries, Ghana has insufficient resources to address all health and other concerns of the nation. While the burden of non-communicable diseases is growing and is likely to be the leading health concern some time in the foreseeable future, Ghana's current health challenges still skew heavily towards causes like neonatal disease, malaria and diarrhea (IHME, 2019). A key question for decision makers, therefore, is whether the benefits of addressing hypertension outweigh the benefits from alternative uses of scarce resources.

This paper assesses the costs and benefits of a community health worker led screening and treatment program for individuals aged 30 and above. As noted, a key challenge in Ghana is limited awareness of hypertension status for much of the hypertensive population. Mass screening seeks to address this lack of knowledge. Additionally, given the shortage of doctors in Ghana and the recent evidence that non-physicians can screen and manage uncomplicated hypertension cases (Adler et al. 2019; Ogedegbe et al, 2018), we assess the effectiveness of a community health worker led strategy.

This paper builds upon a recent cost-effectiveness exercise conducted for the Ministry of Health under the International Decision Support Initiative (iDSI) Health Technology Assessment (HTA) program. That exercise sought to ascertain the most cost-effective treatment strategy for those currently aware and being treated for hypertension from the perspective of the government (Chalkidou, Lord and Gad, 2017). Results indicated that compared to no treatment, treating patients with diuretics avoided a disability adjusted life year (DALY) at a cost of GH¢ 642. Switching patients to diuretics could improve health outcomes while saving the government money over five years. This analysis complements the HTA study, since it focuses on a different aspect of the hypertension problem – i.e. those unaware of their hypertension status.

Our results show that under plausible parameter assumptions, community health worker screening and treatment of hypertension is an effective use of societal resources, with a benefit-cost ratio (BCR) of 3.3. Our analysis suggests, for every 25,000 individuals screened, 2,282 would start treatment. With a treatment regime of diuretics and 30 percent adherence after five years, the intervention is expected to avoid 29 deaths (505 life years), 11.1 cases of heart disease, 0.1 cases of stroke and 1.6 heart failures. While overall health outcomes would improve for the population screened, it would however lead to the onset of 1.1 cases of diabetes relative to no intervention. Over ten years, these benefits are worth GH¢ 7.1m[4] at an 8 percent discount rate. This intervention would cost GH¢ 2.2m in health system, private and other economic costs over the same time period. These figures are for an intervention screening 25,000 individuals and would likely scale linearly with larger populations.

Overall, the analysis indicates that while returning GH¢ 3.3 in benefits relative to every GH¢ 1 spent, there are likely to be more effective uses of societal resources in Ghana, for example addressing malaria or nutrition challenges (see Aryeetey et al. 2019; Nketiah-Amponsah et al. 2019). Nevertheless, the BCR of the intervention would increase if adherence to hypertension could improve, the screened population focused on sub-groups with higher levels of hypertension prevalence (such as individuals aged 40 or 50 and above), or the general population prevalence of hypertension rises. In regard to the last factor, given the observed trend of increasing non-communicable diseases as economies become wealthier, it would be

[4] This paper was written for the benefit of Ghanaian policy makers and therefore all figures are presented in (2018) cedis. The relevant GH¢ to USD exchange rate for this analysis is 4.56.

worth re-estimating the results, and the policy implications, at some point in the near future, particularly given Ghana's rapid growth trajectory.

2. Community health worker led screening and treatment for hypertension

2.1 Intervention context

2.1.1. Description of intervention

The intervention envisages a cadre of community health workers visiting households to screen individuals for hypertension and other cardiovascular disease risk factors. We limit the target group to those aged 30 and above since the prevalence of hypertension is relatively low at younger ages (see Table 1). Additionally, we assume that individulas who are aware of their hypertension status would not participate in the screening. Individuals who are assessed as having high blood pressure are referred onto a health facility for further assessment and, if deemed necessary by the medical practitioner, placed on medication. Following the recommendations of Chalkidou, Lord and Gad (2017), we envisage that individuals are placed on diuretics in the first instance.[5] In line with recent developments towards increased task shifting and demonstrated ability of nurses to successfully manage hypertension (Ogedegbe et al, 2018), we assume community health workers manage those with mild or moderate hypertension while physicians manage those with severe hypertension.[6]

2.2.1. Literature review

Hypertension Screening and Treatment in Ghana and Africa

In Ghana, population-based studies have shown increase in hypertension prevalence and its significant impact on stroke morbidity and mortality, over the last four decades. However, despite this, hypertension awareness, treatment and control are poor in the country (Sanuade et al, 2018). Generally speaking, the literature demonstrates relatively low yields from screening.

[5]Other drug classes like calcium channel blockers (which pysicians in Ghana commonly prefer as the first line of treatment) are likely to be more expensive and associated with a lower BCR as demonstrated in the sensitivity analysis.

[6]Following from our discussions with experts on the subject of hypertension treatment, it seems further policy debate is needed on the legal basis and capabilities of community health workers to manage hypertension. Current protocols in Ghana restrict treatment of hypertension to only physicians. Nevertheless this has not prevented trials of community led programs to be run as noted in Adler et al. (2019) and Ogedegbe et al. (2018).

Adler et al. (2019) describes an intervention undertaken by community nurses to screen, treat and manage hypertension in the Lower Manya Krobo District in the Eastern Region of Ghana. The study screened 18,339 individuals aged 18+ of which 4,118 were shown to be at risk of hypertension and referred for further treatment. Of these only 1,339 actually enrolled in the program and about half (627) actually started any form of medication or participated in a follow up meeting at 6 months or 12 months. The result (627 / 18,339) represents a 3.4 percent yield from the intervention. After 1 year of intervention, 72 percent of participants had their hypertension under control with systolic BP reduced by 12.2 mm Hg and diastolic BP by 7.5 mm Hg.

Ogedegbe et al. (2018) conducted a study to evaluate the comparative effectiveness of provision of health insurance coverage (HIC) alone versus a nurse-led task shifting strategy for hypertension control (TASSH) plus HIC on systolic blood pressure (SBP) reduction among patients with uncontrolled hypertension in Ghana. A total of 2,779 patients were screened and 757 enrolled, with an 85 percent completion rate at 12 months. The study used a cluster randomized controlled trial conducted among 757 patients with uncontrolled hypertension across 32 community health centers in Ghana. The study found that the addition of a nurse-led intervention to provision of health insurance coverage led to a greater reduction in systolic BP (−20.4 mm Hg) than health insurance coverage alone (−16.8 mm Hg), with a net difference in reduction of 3.6 mm Hg ($p = 0.021$) at 12 months.

Other studies from Ghana and other African countries demonstrate the ability for screening and treatment to reduce blood pressure levels in patients. Marfo and Owusu-Daaku (2016), in their study on Ghana, found that the intervention group recorded a reduction of -9.28 mmHg and -9.04 mm Hg in systolic and diastolic pressure as compared to the control group who recorded a reduction of -1.34 mm Hg in systolic pressure. In Nairobi, a significant reduction of mean systolic and diastolic pressure (150.4 mmHg to 141.5 mmHg, and 89.3 mmHg to 83.2 mmHg,) was seen for all patients that stayed in care for at least one year (Werner et al. 2015).

Economic Analyses of Hypertension Control Strategies

As the global proportion of deaths from non-communicable diseases (NCDs) has grown, there has been an increase in studies estimating investment strategies to prevent and control NCDs. Bertram et al. (2018) proposed a methodology for calculating the economic benefits of investing in NCDs during the Sustainable Development Goals (SDGs) era, applying it to cardiovascular disease prevention in 20 countries with the highest NCD burden. For a limited set of prevention interventions, the study estimates that US$120 billion must be invested in these countries between 2015 and 2030. This investment represents an additional $1·50 per

capita per year and would avert 15 million deaths, 8 million incidents of ischaemic heart disease, and 13 million incidents of stroke in the 20 countries. Benefit–cost ratios varied between interventions and country-income levels, with an average ratio of 5·6 for economic returns but a ratio of 10·9 if social returns are included. Nugent, (2015) found that hypertension management was a cost-effective intervention even at 50 percent coverage with a BCR of 23. The study showed that effective hypertension control for even half of medium to high risk patients would avert .77 million deaths, or 15.4 million DALYs at a ratio of $23 in benefits per $1 spent. A study in Haiti by the Copenhagen Consensus Center (CCC) (McBain et al. 2017) found the BCR of hypertension screening and treatment intervention to be 1.74 at 5 percent discount rate. Similar studies by CCC found the BCR to be much higher at 17.8 in Bangladesh (Koehlmoos et al. 2016), and 31 and 23 in the two states of Andhra Pradesh and Rajasthan in India, respectively (Seshadri and Hebbare, 2017a; Seshadri and Hebbare, 2017b).

Chalkidou, Lord and Gad (2017) studied the cost effectiveness of four main classes of antihypertensive drugs to treat hypertension in Ghana (ACE inhibitors/ARBs, Beta-blockers-BB, calcium channel blockers-CCBs, thiazide-like diuretics -TZDs, and no interventions. Diuretics cost about GH¢ 300,000 more per 1,000 patients treated, and avoid about 450 DALYs: giving an Incremental Cost-Effectiveness Ratio (ICER) of GH¢ 642 per DALY avoided. Using a CCB rather than diuretic was found to cost an additional GH¢ 5.2 million and avoided a further 160 DALYs: an ICER of over GH¢ 30,000 per DALY avoided. Compared with TZD, CCBs were estimated to be more effective (with more DALYs avoided) but more expensive.

Other global studies on cost-effectiveness analyses evaluate population-based screening interventions. Gu et al, (2015) showed that if physicians would screen all adults aged 35–84 years and treat all identified stage II hypertensive patients in China, it would cost $9,000 per quality adjusted life year (QALY), and was cost effective based on a willingness-to-pay benchmark used in China ($11,900 per QALY). In Nigeria, Rosendaal et al, (2016) compared two strategies to no screening; strategy 1 entailed hypertension screening and treatment for those with stage 1 hypertension and strategy 2 entailed screening and treatment of all hypertensive people with CVD risk > 20 percent. The second strategy was found to be cost-effective while strategy 1 was only moderately cost-effective with a tendency to be dominated. The mean ICERs for the risk and hypertension-based strategy (strategy 2) were US$ 7,815 using the Framingham assumption, US$ 6,256 using the Rapsomaniki assumption and US$ 1,406 using the Lawes assumption. Gaziano et al, (2015) evaluated paper-based and mobile app-based CVD screening by community health workers compared to standard care

(opportunistic screening). The mobile app was cost effective in Mexico and Guatemala, with an incremental cost-effectiveness ratio of $565 per QALY gained in Guatemala and $3.57 per QALY gained in Mexico. The use of the mobile application was however only cost-saving (it increased QALYs and reduced overall costs) in South Africa.

2.2 Calculation of Costs and Benefits

2.2.1 General assumptions

The analysis follows a cohort of 12,500 men and 12,500 women who are screened in the initial year of the intervention (2018). This population size is set to approximate the average number of individuals in the target population (30 years and older) in a standard district in Ghana. The cohort is assumed to be representative of the wider population in the target age group. Note, that the choice of cohort size is somewhat arbitrary and an analysis on different sized groups would not affect the benefit-cost ratio in most cases.[7]

Our analysis stratifies the target population into five age sub-groups (10-year increments between 30 and 69 plus one age group for all those over 70), two gender sub-groups (men and women) and four hypertension sub-groups (none/controlled, mild, moderate and severe). In total we have 40 sub-groups each with different age-gender-hypertension characteristics. Population across the various age cohorts is estimated from IIASA projections while underlying hypertension prevalence rates for each age-gender sub-group up to age 49 are drawn from Ghana Statistical Service (2015), and the rest from those calculated by Chalkidou, Lord and Gad (2017).

Some of the screened individuals start medication and the analysis estimates the health benefits from a ten-year treatment regime relative to no-intervention.

Following *Ghana Priorities* standardized assumptions, we use discount rates of 5 percent, 8 percent and 14 percent, and assume growth rates in GDP, population and therefore GDP per capita from (modified) IIASA projections (Wong and Dubosse, 2019).

[7] The costs would likely be higher for an analysis on a very small group of screened individuals due to the presence of high fixed programmatic costs that could not be spread over a large beneficiary population. On the other hand, an analysis that assumes close to universal screening would also likely have higher costs since reaching the remotest parts of Ghana would be prohibitively expensive.

2.2.2. The yield from screening

It is assumed that screening of the target population would lead to detection and referrals equal to each age-gender group's surveyed hypertensive prevalence, i.e. those depicted in Table 1. This represents the theoretical maximum yield from screening and would occur if all people follow up their referrals. However, existing literature from Ghana and elsewhere demonstrates significant reticence on the behalf of individuals to follow up on referrals from mass screening.

For example, Adler et al. (2019) screened 18,339 individuals aged 18+ of which 4,118 were shown to be at risk of hypertension and referred for further treatment. Of these only 1,339 actually enrolled in the program and about half (that is 627) actually started any form of medication or participated in a follow up meeting at 6 months or 12 months. The result (627 / 18,339) represents a 3.4 percent yield from the intervention. Another smaller study by Marfo and Owusu-Daaku (2016), also from Ghana, screened 170 individuals aged 45+ who were obese or pregnant with only 10 eventually starting medication (5.9 percent yield). Ogedegbe et al. (2018) demonstrate a higher yield, however the screened population in that paper was drawn from individuals who already had a high blood pressure reading and so was not representative of general hypertension case finding.

Similarly modest yields have been obtained in other contexts for example, a 3.0 percent yield in Nigeria (Nielsen et al, 2018), 3.9 percent yield in South Africa (Seidner et al. 2018), 9.1 percent yield in Malawi (Musicha et al. 2016), 7.9 percent yield in Uganda (Kotwani et al. 2014) and a 1.2 percent yield in a combined study of Bangladesh, Guatemala, South Africa and Mexico (Levitt et al. 2015). Table 3 below summarises the available evidence on screening yields.

Table 3: Summary of Hypertension Yield from Studies in Ghana and Africa

Study	Location	Screened population	Screened sample size	Yield
Adler et al 2019	Eastern region of Ghana	18+ men and women	18,339	3.4%
Marfo and Owosu Daakuu 2016	Ghana	45+ men and women who were obese or pregnant	170	5.9%
Nielsen et al 2018	Lagos, Nigeria	18-75 men and women	3,204	3.0%
Seidner et al 2018	Rural South Africa	18-47 men and 23-55 women	11,694	3.9%
Musicha et al 2016	Malawi	30+ men and women	27,305	9.1%
Kotwani et al 2014	Rural Uganda	18–65 men and women	2,252	7.9%
Levitt et al. 2015	Bangladesh, Guatemala, South Africa and Mexico	Varies by location	4,101	1.2%

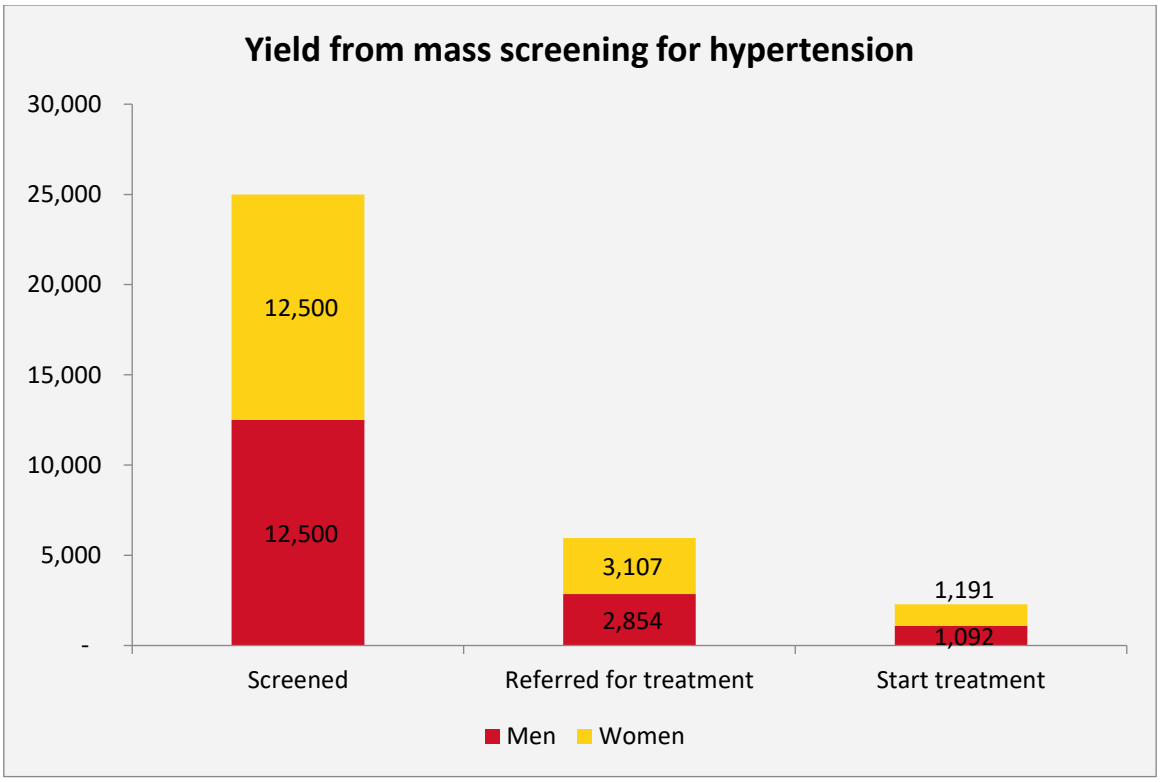
Source: Author's summary of evidence from Review of literature

For this analysis we draw response parameters from Adler et al. (2019) since it is recent, context-relevant study with a large sample size.

We had initially assumed that those with worse hypertension would be more motivated to act and follow up on their referral. However, the data in Adler et al. (2019) shows the opposite relationship, with response to referrals of 30 percent, 38 percent and 47 percent for those with Stage III (most severe), Stage II and Stage I cardiovascular risk respectively. One potential explanation of this result is that there is some unobserved characteristic driving both variables, meaning those who have worse hypertension are also those who are less likely to seek treatment. We apply these parameters to the relevant hypertension sub-groups (severe, moderate and mild respectively). The results are not granular enough for us to use follow up parameters that differ by age or gender. Finally, Adler et al. (2019) also shows that of those who followed up on their referrals, more than 90 percent were on medication after 12 months. We apply 90 percent parameter as a final filter.

Our model demonstrates a yield of 9.1 percent based on screening the target population of 30+. For every 12,500 women screened we expect 1,191 of them to start medication, whereas for men the equivalent number is 1,092 (see Figure 1 below). This yield is higher than the one derived in Adler et al. (2019), but their study screened those aged 18 and above – a group which would have a lower average prevalence of high blood pressure. A more relevant comparator study is Musicha et al. (2016), which screened men and women aged 30+ in Malawi and demonstrated a yield of 9.1 percent - a figure the same as our estimate.

Figure 1: Yield from Mass Screening for Hypertension



2.2.3. Adherence to medication

A recent meta-analysis demonstrates that adherence to hypertension medication globally is 55 percent (Abegaz et al. 2017). There are four studies that provide information on hypertension medication adherence in Ghana - two as observational studies of hypertension patients (Kretchy, Owusu-Daaku and Danquah, 2013, Buabeng, Matowe and Plange-Rhule, 2004) and two as part of pilot interventions of innovative programs (Adler et al. 2019; Ogedegbe et al, 2018).

The two observational studies both show an alarmingly low adherence rate of around 7 percent. Buabeng, Matowe and Plange-Rhule (2004) investigate compliance among new hypertensive patients after 3 months. They attribute poor compliance to the cost of medication.[8] Kretchy, Owusu-Daaku and Danquah (2013) do not indicate how long patients interviewed in their analysis had been on medication, only that inclusion into the study required that a patient be prescribed a hypertensive drug in the last six months. Neither study had longer term follow up.

[8] Data for this study was gathered between December 2001 and April 2002 before Ghana's National Health Insurance scheme was fully operational and when Ghana was significantly less wealthy than today. It is unclear whether cost remains an impediment to adherence in 2019.

These low adherence rates from the two observational studies contrast with the findings from the two program studies. In Adler et al. (2019) there was almost no attrition in the first 12 months. In Ogedegbe et al. (2018) around 80 percent of patients completed the 24-month follow up. While the results of these studies are more recent and perhaps more closely reflective of current conditions and strategies for hypertension management, it is possible that the programmatic structure of these interventions increased adherence to the treatment regime, and would not be observed if the intervention were scaled using government resources.[9] In any case, we have no evidence beyond two years.

Broadly following these studies, we therefore assume that adherence is 85 percent in the first year, 75 percent in the second year, 55 percent in the third year (reflective of global average), 40 percent in the fourth year and then continues at 30 percent in subsequent years (acknowledging evidence of poor adherence from observational studies). Due to lack of more granular data we also assume that these rates apply equally to all patients regardless of age, gender or hypertension status. Since stopping hypertension medication raises blood pressure to pre-medication levels within a matter of weeks, we model non-adherence as a proportional reduction in benefits relative to full compliance, i.e. 75 percent adherence implies 75 percent of benefits relative to full compliance. For costs, we adopt the same approach – i.e. 75 percent adherence implies only 75 percent ongoing treatment and management costs are incurred relative to full compliance. This assumption only reduces ongoing costs and benefits, and does not affect the initial one-off cost of screening and referral. Therefore, lower adherence serves to increase the relative weight of the initial one-off screening and referral costs and also lowers the BCR.

2.2.4 Costs

There are two broad categories of costs – the one-off costs of screening and referral, and the ongoing costs of treatment and management.

Screening and referral costs

There does not appear to be any Ghana specific data on screening costs so we draw from Gaziano et al. (2015) which estimates the costs of screening by community health workers for three countries, Guatemala, South Africa and Mexico using two methods - phone and paper-based screening. In their study, costs ranged from 0.64 USD to 5.19 USD per person screened

[9] There is increasing acknowledgement that the experimental structure of RCTs might not be representative of effects 'at-scale' (see Muralidharan and Neihaus, 2017 for a more in-depth discussion of this phenomenon).

depending on country and method (2012 USD). We convert these to costs as a percentage of GDP per capita PPP (after converting to Int$) and note that the average paper (phone) based method costs 0.04 percent (0.02 percent) of GDP per capita PPP per person screened.

Applying these ratios to Ghanaian GDP per capita PPP for 2018, suggests a range of GH¢ 9.1-17.1 per person screened. In the following analysis we report costs using the mid-point of GH¢ 13.2 per person screened. The estimated direct screening cost is GH¢ 330,500 for 25,000 people. We also assume time for each screening is 12.5 min (survey data collected by the authors) and value this at 50 percent of wage rate as per *Ghana Priorities* standardized approach. The estimated time cost for 25,000 people is GH¢ 16,400. The analysis from Section 2.2.2 indicates that 2,536 individuals seek treatment upon a reading of elevated blood pressure. We estimate the direct cost of a physician examination at GH¢ 90 and GH¢ 4 for time of 1.25 hours per patient including travel for a total initial referral cost of GH¢ 244,200.

The total costs of screening 12,500 men and 12,500 women and referring 2,536 individuals are therefore estimated at GH¢ 591,000. This cost is incurred only once at the start of the intervention timeline.

Treatment and management costs

The treatment costs for diuretics are drawn from Chalkidou, Lord and Gad (2017) who identify a medication cost of GH¢ 26 per person per year.

To this we add the costs of patient management by physicians for severe hypertension and community health workers for moderate and mild hypertension. We assume that those diagnosed with severe hypertension are managed by physicians, requiring four visits per year (based on survey data collected by the authors and confirmed by participants at the Ghana Priorities October 2019 roundtable). Those with moderate and mild hypertension are assumed to require 1 physician visit and 3 visits to community health workers a year. For physician visits, we assume a direct cost of GH¢ 90 per visit and two hours time requirement including travel and wait time (survey data collected by authors). For community health worker visits, we estimate a resource cost based on a monthly salary of GH¢ 1,500, that is for 22 working days per month, 8 hours of work per day and two hours per visit (including time travelling between patients, breaks and other coordinating activities) for a total per visit cost of GH¢ 17. The total costs of case management for those with mild and moderate hypertension are therefore GH¢ 141 per year.

Overall management and drug costs are approximately GH¢ 395,000 in the first year and decline to GH¢ 138,000 by year five of the intervention due to attrition (see appendix for year to year undiscounted breakdown of costs and benefits). Drugs only make up 7 percent of the ongoing cost profile, while case management comprises two thirds of costs.

2.2.3 Benefits

The effect of hypertension medication on health outcomes

Commencing treatment should lead to a reduction in blood pressure and hence a reduction in the risk of hypertension related morbidity and mortality. In order to estimate the benefits of hypertension treatment, we use a Markov model previously created for a hypertension modelling exercise in Ghana (Chalkidou, Lord and Gad, 2017). Here we provide a broad overview of the model and changes made to the original analysis. The interested reader should consult the appendix of Chalkidou, Lord and Gad (2017) for further details.

The Markov model traces the outcomes of individuals who have various levels of hypertension through six potential states – no event, non-fatal heart disease, non-fatal stroke, onset of heart failure, onset of diabetes and death. For tractability the model only allows individuals to be in one state per cycle (set here to one year). The probability of transitioning to each state is based on the baseline risk of diseases for a given age-gender sub-group[10] and is augmented by the severity of hypertension using risk ratios from Singh et al. (2013) except for diabetes which uses incidence rates from QDiabetes algorithm. Following a non-fatal cardiovascular event, the model assumes that baseline risk of death doubles. These probabilities reflect the no intervention scenario where individuals do not undertake preventative treatment for hypertension.

The Markov model adjusts transition probabilities for those on hypertension medication. Diuretics were found to reduce systolic blood pressure by an average of 11.8mm HG in black populations, following the meta-analysis of Brewster et al (2004), and this is converted into relative risk reductions of the five adverse event states following Ettehad et al. (2016) (for CHD, stroke, heart failure and death) and Elliot et al (2007) (for diabetes). The resulting risk reductions for various disease states diuretics are presented below in Table 4.

[10] Baseline risk of cardiovascular disease (stroke, heart failure and heart disease) is based on analysis conducted on black African patients living in the UK (QRisk 2 algorithm) since there appear to be no Ghana-specific cohort studies with long term follow up. The baseline risk of deaths if from WHO life tables from Ghana.

Table 4: Relative risks from treatment on diuretics (from Chalkidou, Lord and Gad, 2017)

Disease State	Relative risk of adverse event vs. control
CHD	0.82
Stroke	0.66
Heart failure	0.51
Diabetes	1.15
Death	0.87

We run the model for the no-intervention and intervention state and take the difference between the two outcomes to estimate the health benefits. The model reports cases of heart disease, stroke, heart failure and diabetes avoided and associated costs, as well as DALYs avoided from which deaths avoided can be inferred. This is reported for each age-gender-severity sub-group and is matched to the individuals who start treatment.

The original analysis by Chalkidou, Lord and Gad (2017) was designed as a cost-effective analysis from the perspective of the government. This analysis makes several changes to the underlying parameters of the Markov model used in Chalkidou, Lord and Gad (2017) to better fit the purpose of this paper (i.e. a social cost-benefit analysis for *Ghana Priorities* project). [11] First, we update population to 2018 estimates based on the International Institute for Applied Systems Analysis (IIASA) data whereas the original analysis used 2010 census data. Second, we use life tables from Ghana to estimate years of life lost per death avoided, as opposed to Japanese life tables adopted in the original analysis. This is done to ensure comparability between other studies in the *Ghana Priorities* series. Third, and most consequentially, we update cost figures for the adverse event states to reflect total societal costs, including out-of-pocket expenses and private costs incurred by individuals such as travel and lost productivity. The original analysis only focused on NHIS costs.

The results indicate that in the first year, the intervention avoids 5.63 deaths equivalent to 99 years of life lost. It also avoids 2.2 cases of heart disease, 0.02 strokes and 0.31 heart failures. The intervention also causes the onset of 0.2 cases of diabetes. The benefits of the intervention slightly favor men over women. These health outcomes are outputs from the Markov model, with an adherence discount applied as discussed above.

[11] Preliminary analysis indicates that the policy recommendations from the original analysis (i.e that diuretics are the most cost-effective first line drug option for managing hypertension in Ghana) still hold under these new parameter values.

Table 5: Health outcomes in the first year (85% compliance) relative to no intervention

	YLLs avoided	Deaths avoided	Cases of CHD avoided	Strokes avoided	Heart failure avoided	Type 2 diabetes avoided
Men	51.1	2.7	1.2	0.01	0.1	-0.1
Women	47.7	2.9	0.9	0.01	0.2	-0.1
Total	98.7	5.6	2.2	0.02	0.3	-0.2

In subsequent years, benefits are reduced by a factor equal to the respective year's assumed adherence rate. In total, over 10 years an intervention which screens 25,000 individuals aged 30 and above, followed by treatment on diuretics with a long-term compliance rate of 30 percent is expected to avoid 29 deaths (505 life years avoided), 11.1 cases of heart disease, 0.1 cases of stroke and 1.6 heart failures. It will lead to the onset of 1.1 cases of diabetes. As discussed previously, we expect these results to scale with the number of screened individuals.

The benefits of years of life lost are valued according to *Ghana Priorities* standard assumptions, (Wong and Dubosse, 2019) while morbidity is assessed using a cost-of-illness approach. In the initial year, 2018 each year of life lost is valued at 1.2x GDP per capita rising to 1.5x GDP per capita by the end of the intervention period.

The costs associated with the various adverse events are presented below in Table 6. When an adverse event occurs, there is a large initial cost associated with managing the event. In subsequent years, the individual is assumed to undergo less costly, but still substantial observation by the physician. The costs below represent full societal costs and account for health system costs incurred, out-of-pocket expenses, travel time for the individual and a relative as well as lost productivity (see appendix for full breakdown of costs).

Table 6: Costs associated with each adverse event

Event	**Cost in first year** (2018 GH¢)	**Cost in subsequent years** (2018 GH¢)
CHD	6,330	2,914
Stroke	7,049	3,210
Heart Failure	8,369	2,725
Diabetes	6,731	2,489

Total benefits from the intervention are summarized in Table 7 below.

Table 7: Summary of benefits from intervention

Discount rate	Mortality avoided benefit (millions of 2018 GH¢)	Morbidity avoided benefit (millions of 2018 GH¢)	Total benefits (millions of 2018 GH¢)
5%	6.67	1.10	7.76
8%	6.07	1.01	7.08
14%	5..16	0.88	6.04

Note: results represent benefits of a screened population of 12,500 men and 12,500 women, 9.1% of whom start medication on diuretics with 30% long term adherence rate

The results indicate that the total benefits of the intervention equal GH¢ 6.0 million to GH¢ 7.8 million depending on the discount rate applied. Mortality avoided benefit comprises approximately 85 percent of the total benefit.

2.2.4 Summary of Cost Benefit Analysis

The results of the cost benefit analysis are summarized below in Table 8.

Table 8: Summary BCR Table

Intervention	Discount Rate	Benefit	Cost	BCR
Community health worker led screening and treatment for hypertension	5%	7.8	2.3	3.4
	8%	7.1	2.2	3.3
	14%	6.0	2.0	3.1

The analysis indicates that the intervention has a BCR of 3.1 to 3.4 depending on the discount rate applied. The central estimate indicates a BCR of 3.3 with total benefits of GH¢ 7.1 million and total costs of GH¢ 2.2 million.

2.2.5 Sensitivity Analysis

The results of the above CBA of community health worker led screening and treatment for hypertension are conditional on a range of assumptions, specifically on the magnitude of the included parameters. Sensitivity analyses are therefore important to provide an indication of the robustness of the results with respect to reasonable deviations and uncertainties from the anticipated values. Some of the key parameters are: (i) attrition rates under the treatment regime, which was largely drawn from the scanty and inconsistent empirical literature; (ii) the ongoing costs of case management which was observed in the primary analysis as the main cost driver and (iii) alternative treatment option for hypertension based on calcium channel

blockers, which, according to expert opinion, is one of the first line treatment options preferred by physicians in Ghana over diuretics.

Clearly, to make such an exercise worthwhile, reasonable higher and lower values of the parameters need to be established. In the case of adherence, we first show results for higher adherence, starting at 100% in the first year and continuing to 85%, 75%, 65% before leveling off at 55% - the global average over the remaining years. In order to reflect long run adherence from observational analysis, we further explore the effects of lower levels of adherence, starting at 75%, through 55%, 35%, 20% to 7% for remaining years. Higher levels of adherence increase both ongoing benefits as well as drug and case management costs. This reduces the relative share of the initial screening and referral costs leading to higher BCRs. A similar argument can be made for lower levels of adherence. The results in Table 9 show relatively small changes to BCRs, with a range between 2.5 and 3.8 depending on the level of adherence assumed and discount rate.

Table 9: Simulations with High and Low Levels of Adherence - Summary BCR Table

Intervention	Discount Rate	Benefits (GH¢ millions)		Costs (GH¢ millions)		BCR	
		High Adherence	Low Adherence	High Adherence	Low Adherence	High Adherence	Low Adherence
Community health worker led screening and treatment for hypertension	5%	11.7	4.1	3.1	1.5	3.8	2.6
	8%	10.5	3.8	2.9	1.5	3.7	2.6
	14%	8.7	3.5	2.5	1.4	3.5	2.5

Next, we investigate the sensitivity of the analysis with respect to high and low-cost values on the management of hypertension by physicians and CHWs. In particular, for the upward adjustments, we consider an increase in the direct cost of physician visits from GH¢ 90 to GH¢ 120 and that of CHWs from GH¢ 1,800 as monthly salary. Furthermore, the costs are updated so that treatment of severe hypertension requires 6 physician visits and for mild and moderate hypertension, patients require 2 physician and 4 CHWs visits.12 In terms of sensitivity analysis to validate the robustness of the results with respect to lower cost values, we consider a downward adjustment of physician visit cost to GH¢60 and GH¢1,200 per month salary for

[12] The basis for these changes were based on feedback and comments received from stakeholders during the review workshop held by the Copenhagen Consensus Centre in collaboration with the Ghana Health Service.

CHWs. The number of patient visits to physicians for severe hyptension is also reduced to 2 while that for moderate and mild hypertension require 1 physican visit and 2 CHW visits.

The summary BCR results are as shown in Table 10. Higher costs generate a lower BCR of 1.7. This is based on a new estimated cost of GH¢4.2m and same benefits of GH¢7.1 over 10 years at a discount rate of 8%. The simulation results associated with low variation of ongoing cost of managing hypertension scenario yields a higher BCR of 5.1, compared to a lower BCR of 3.3 in the original analysis. As anticipated, varying the case management costs of hypertension has a larger relative effect on the BCR. This highlights the need to explore the possibility of using CHWs and lighter-touch models of case management for hypertension to improve the overall effectiveness of the intervention.

Table 10: Simulations with Variations in Ongoing Cost of Management and Treatment of Hypertension - Summary BCR Table

Intervention	Discount Rate	Benefits (GH¢ millions)		Costs (GH¢ millions)		BCR	
		High Costs	Low Costs	High Costs	Low Costs	High Costs	Low Costs
Community health worker led screening and treatment for hypertension	5%	7.8	7.8	4.5	1.3	1.7	6.2
	8%	7.1	7.1	4.2	1.2	1.7	5.9
	14%	6.0	6.0	3.8	1.1	1.6	5.5

Lastly, we conduct a sensitivity analysis based on treatment regime of calcium channel blockers (CCB) instead of diuretics. Effect sizes for CCB are from Chakidou, Lord and Gad (2017) and are in-built into the Markov Model. Analysis shows that benefits are greater at GH¢ 9.3m over ten years at an 8% discount rate. CCB would lead to 39 deaths avoided (682 life years), 13.8 cases of heart disease, 0.1 cases of stroke, 0.6 cases of heart failure and 1.3 cases of diabetes avoided. However drug costs are significantly higher for CCB (almost GH¢400 compared to GH¢26 for diuretics), which leads to approximately doubling the total costs of the intervention.

Table 11: Simulations with Variations in Class of Drug from Diuretics to Calcium Channel Blockers (CCB) - Summary BCR Table

Intervention	Discount Rate	Benefits (GH¢ millions)		Costs (GH¢ millions)		BCR	
		Diuretics (original)	CCB	Diuretics (original)	CCB	Diuretics (original)	CCB
Community health worker led screening and treatment for hypertension	5%	7.8	10.2	2.3	4.7	3.4	2.2
	8%	7.1	9.3	2.2	4.4	3.3	2.1
	14%	6.0	7.9	2.0	3.9	3.1	2.0

3. Conclusion

The cost benefit analysis indicates that community health worker led mass screening and treatment of individuals aged 30 and above for hypertension would lead to substantial benefits relative to costs. For every 25,000 individuals screened, our analysis suggests 2,282 would start treatment. With a treatment regime of diuretics and 30 percent adherence after five years, the intervention is expected to avoid 29 deaths (505 life years), 11.1 cases of heart disease, 0.1 cases of stroke and 1.6 heart failures. While overall health of the screened population improves, it will also lead to the onset of 1.1 cases of diabetes, relative to no intervention. These benefits are worth GH¢ 7.1 million over ten years at an 8 percent discount rate. The costs of the intervention are GH¢ 2.2 million, resulting in an overall BCR of 3.3. Sensitivity analyses indicate that the result is most sensitive to assumptions concerning ongoing costs of case management of hypertension.

There are some important limitations to this analysis. First, the finer details of the exact screening method have not been specified and accounted for in this study. Other analyses have demonstrated that the type of screening approach, including the location of blood pressure reading and the desired cut-off levels for referral can affect the sensitivy and specificity of the screening tool with non-trivial implications on cost-effectiveness (NICE, 2011). Second, the overall evidence base is somewhat limited requiring us to make strong assumptions for some parameter values. For example, the screening response parameters are drawn from Adler et al. (2019), a study conducted in a rural area of Ghana. It is possible that the response rate would be higher in an urban setting with potentially easier access to health facilities but to the best of our knowledge no studies from urban setting are available. The Markov model used in this study utilizes probabilities of adverse events from longitudinal studies of black populations in the UK since there is limited Ghana specific information. Costs for screening are drawn from

Gaziano et al (2015), a study conducted in four developing countries outside of Ghana. Third, the intervention assumes a treatment regime of simply diuretics. While we feel this is a reasonable strategy in the first instance, individuals respond differently to different drugs. In reality, if treatment does not appear to control hypertension, physicians are likely to recommend a patient try different drug classes, as was confirmed by experts consulted during the study. This would increase benefits but may also change costs with uncertain implications. That said, given that diuretics were shown as the most cost-effective drug class (Chakidou, Lord and Gad, 2017), switching to another drug class is likely to reduce the overall BCR. Sensitivity analyses conducted assuming treatment with CCB instead of diuretics confirmed this. Hypotension was mentioned by stakeholders as a source for clinical concern that requires attention by policy makers in Ghana but this was not addressed in this study.

Despite these limitations, the analysis indicates that the BCR is unlikely to be higher than alternative uses of funds in Ghana for example addressing malaria and nutrition which have BCRs perhaps 10 times as large. However, it likely represents a more efficient investment than some sanitation and poverty reduction programs (see rural sanitation and poverty papers in the Ghana Priorities series). Additionally, it is possible that in the future hypertension screening will have a more favorable BCR relative to alternatives when NCDs comprise a greater share of the disease burden in Ghana. It is therefore worth revisiting this analysis and policy implications at a future date.

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Appendix

Timeline of undiscounted costs and benefits

Timeline year	1	2	3	4	5	6	7	8	9	10
Calendar year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
OUTCOMES										
Number screened	25,000									
Number referred	5961									
Number seek treatment	2536									
Attrition rate	85%	75%	55%	40%	30%	30%	30%	30%	30%	30%
Number on treatment	1940	1712	1255	913	685	685	685	685	685	685
Number on treatment severe	191	169	124	90	67	67	67	67	67	67
Number on treatment, mild and moderate	1793	1543	1132	823	617	617	617	617	617	617
Deaths avoided	5.63	4.97	3.64	2.65	1.99	1.99	1.99	1.99	1.99	1.99
YLLs avoided	99	87	64	46	35	35	35	35	35	35
CHDs avoided	2.16	1.91	1.40	1.02	0.76	0.76	0.76	0.76	0.76	0.76
Strokes avoided	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HF avoided	0.31	0.27	0.20	0.14	0.11	0.11	0.11	0.11	0.11	0.11
T2D avoided	-0.20	-0.18	-0.13	-0.10	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
COSTS										
Screening costs	346,884									
Referral costs in first instance	244,181									
Drug costs	36,780	32,453	23,799	17,308	12,981	12,981	12,981	12,981	12,981	12,981
Direct costs of doctor visits	68,757	60,668	44,490	32,356	24,267	24,267	24,267	24,267	24,267	24,267
Direct costs of CHW visits	246,854	217,812	159,729	116,167	87,125	87,125	87,125	87,125	87,125	87,125
Time required for CHW and doctor visits (hour)	10,273	9,065	6,647	4,834	3,626	3,626	3,626	3,626	3,626	3,626
Value of time	32,289	29,583	22,527	16,976	13,193	13,671	14,165	14,678	15,207	15,755
TOTAL COSTS	975,745	340,516	250,544	182,807	137,566	138,044	138,538	139,051	139,580	140,129
BENEFITS										
Costs of care avoided	250,047	220,630	161,795	117,669	88,252	88,252	88,252	88,252	88,252	88,252
Deaths avoided	5.6	5.0	3.6	2.6	2.0	2.0	2.0	2.0	2.0	2.0
YLLs avoided	99	87	64	46	35	35	35	35	35	35
Value of YLLs avoided	1,269,070	1,187,864	920,495	707,862	561,361	593,577	627,646	663,675	702,074	742,702
TOTAL BENEFITS	1,519,118	1,408,493	1,082,290	825,531	649,613	681,829	715,898	751,926	790,326	830,954

Assumptions used for costs of various disease states

	Acute: first cycle after onset					Ongoing: subsequent cycles			
	% patients	Quantity	Unit cost	Cost		% patients	Quantity	Unit cost	Cost
Coronary Heart Disease									
DRG - Acute admission	0.80	2	282	452					
Follow-up specialist consultation	0.80	12	10	96	Specialist visit	0.80	2	10	16
ECO + ECG	0.80	1	360	288	ECG	0.80	2	80	128
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	12	190	1,824	Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	2	190	304
Drugs (Asp, BB, ACEi, Statin)	0.80	365	8	2,321	Drugs (Asp, BB, ACEi, Statin)	0.80	365	8	2,321
Other tests	0.80	1	200	160					0
Other patient costs (travel and food)		12	40	480	Other patient costs (travel and food)	0.80	2	40	64
Lost productivity		14	51	709	Lost productivity	0.80	2	51	81
				6,330					2,914
Stroke					***Stroke***				
DRG - Acute admission	0.80	4	282.35	903.52					
ECO + ECG	0.80	1	360.00	288.00					
Follow-up specialist consultation	0.80	12	10.00	96.00	Specialist visit	0.80	2	10.00	16.00
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	12	190.00	1,824.00	Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	2	190.00	304.00
Drugs (Asp or warfarin, anti-BP, Statin)	0.80	365	9.40	2,744.80	Drugs (Asp or warfarin, anti-BP, Statin)	0.80	365	9.40	2,744.80
Other tests	0.80	1	200.00	160.00					
Other patient costs (travel and food)	0.80	12	40.00	384.00	Other patient costs (travel and food)	0.80	2	40.00	64.00
Lost productivity	0.80	16	50.64	648.21	Lost productivity	0.80	2	50.64	81.03
				7,049					3,209.83

	Acute: first cycle after onset					Ongoing: subsequent cycles			
	% patients	Quantity	Unit cost	Cost		% patients	Quantity	Unit cost	Cost
Heart failure					***Heart failure***				
DRG acute admission	0.80	6	286	1,374					
Consultations (specialist)	0.80	24	10	192	Specialist visit	0.80	2	10	16
ECO	0.80	2	280	448					
ECG	0.80	4	80	256	ECG	0.80	2	80	128
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	12	190	1,824	Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	2	190	304
Drugs (ACEi, BB, Diuretic, Dig, Spiro)	0.80	365	7	2,132	Drugs (ACEi, BB, Diuretic, Dig, Spiro)	0.80	365	7	2,132
Other tests	0.80	1	200	160					
Other patient costs (travel and food)	0.80	24	40	768	Other patient costs (travel and food)	0.80	2	40	64
Lost productivity	0.80	30	51	1,215	Lost productivity	0.80	2	51	81
				8,369					2,725
Diabetes					***Diabetes***				
DRG - Diabetes	0.80	6	166	794					
Consultations (specialist)	0.80	24	10	192	Physician visit (GP)	0.80	2	120	192
ECG	0.80	1	80	64					
Blood tests (PPBG, Lipids, LFT, RFT)	0.80	12	115	1,104	Blood tests (PPBG, Lipids, LFT, RFT)	0.80	2	115	184
Physician visit (GP)	0.80	2	120	192		0.80	0	0	0
Fasting blood glucose	0.80	0	0	0	Annual Eye and feet tests	0.80	1	200	160
Annual eye and feet tests	0.80	1	200	160	Drugs (Hypog, Asp, ACEi, Statin)	0.80	365	7	1,953
Drugs (Hypog, Asp, ACEi, Statin)	0.80	365	7	1,953	Insulin	0.80	8	45	288
Insulin	0.80	8	45	288	Other patient costs	0.80	2	40	64
Other patient costs (travel and food)	0.80	24	40	768	Lost productivity	0.80	2	51	81
Lost productivity	0.80	30	51	1,215					2,489

GHANA PRIORITIES

The Ghanaian economy has been growing swiftly, with remarkable GDP growth higher than five per cent for two years running. This robust growth means added pressure from special interest groups who demand more public spending on certain projects. But like every country, Ghana lacks the money to do everything that citizens would like. It has to prioritise between many worthy opportunities. What if economic science and data could cut through the noise from interest groups, and help the allocation of additional money, to improve the budgeting process and ensure that each cedi can do even more for Ghana? With limited resources and time, it is crucial that focus is informed by what will do the most good for each cedi spent. The Ghana Priorities project will work with stakeholders across the country to find, analyze, rank and disseminate the best solutions for the country.

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Copenhagen Consensus Center is a think tank that investigates and publishes the best policies and investment opportunities based on social good (measured in dollars, but also incorporating e.g. welfare, health and environmental protection) for every dollar spent. The Copenhagen Consensus was conceived to address a fundamental, but overlooked topic in international development: In a world with limited budgets and attention spans, we need to find effective ways to do the most good for the most people. The Copenhagen Consensus works with 300+ of the world's top economists including 7 Nobel Laureates to prioritize solutions to the world's biggest problems, on the basis of data and cost-benefit analysis.