Improving the quality and efficiency of healthcare services in Ghana through HTA

Strengthening health systems and institutions

International Decision Support Initiative, Imperial College London.
Southampton Health Technology Assessments Centre, University of Southampton.

Final report: Cost-effective care for managing hypertension in Ghana, May 2017

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Preface

Every cedi spent within the Ghanaian healthcare system should utilise the best possible value for health gains. More importantly, spending decisions should be backed by robust evidence on cost-effectiveness and budget impact to ensure that there is no other configuration where every participant within the Ghanaian healthcare system is better off. Ghana has a long-standing commitment to Universal Healthcare Coverage (UHC). In 2003 Ghana was the first Sub Saharan African country to introduce a National Health Insurance Scheme (NHIS), aiming to improve access to healthcare and provide financial risk protection for the 28.2 million Ghanaian people.

This report showcases Ghana's consistent efforts and aspirations towards building strong institutional structures for evidence-based policy making and multi-stakeholder engagement. It details the activities of the first HTA pilot study undertaken by the Ghanaian Technical Working Group, supported by the International Decision Support Initiative (iDSI), on cost-effective management of hypertension. The progress highlighted by this report provides a golden opportunity to build on previous efforts to establish a Ghanaian HTA system, with an aim to inform future decisions of the Ghanaian MoH and the NHIA. Understanding the importance of Health Intervention and Technology Assessment (HTA) in support of UHC is crucial for Ghana to take full control over national budgets and allows for optimal resources allocation. This is duly in accordance with resolution WHA67.23, which was approved during the 67th World Health Assembly in May 2014.

The MoH of Ghana is thankful to all the members, institutions, and supporters of these efforts, and would like to praise this progress and encourage further work to provide support to enable full realisation of UHC for the people of Ghana.

Hon Kwaku Agyeman-Manu (MP)

Minister of Health

Accra

Acknowledgments

This project has been supported by the UK's Department for International Development (DFID) and The Rockefeller Foundation.

Local meetings of the Technical Working Group have been supported by the Ghanaian Ministry of Health (MoH) through the UK's Department for International Development (DFID) Technical Assistance Funds.

Imperial College London

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List of Abbreviations

- **ACEi**: Angiotensin Converting Enzyme inhibitor
- **ADP**: Access and Delivery partnership
- **ARB**: Angiotensin Receptor Blocker
- **BB**: Beta blocker
- **CCB**: Calcium Channel Blocker
- **CHD**: Coronary Heart Disease
- **CPD**: Continuing Professional Development
- **CVD**: Cardiovascular Disease
- **DALYs**: Disability Adjusted Life Years
- **DFID**: Department for International Development
- **DHS**: Demographic Health Survey
- **DRG**: Diagnosis Related Group
- **EML**: Essential Medicines list
- **FDA**: Food and Drug Authority
- **FDC**: Fixed Dose Combination
- **GBD**: Global Burden of Disease
- **GHD**: Global Health and Development group
- **HITA**: Health Intervention and Technology Assessment
- **HTA**: Health Technology Assessment
- **ICER**: Incremental Cost-Effectiveness Ratio
- **iDSI**: International Decision Support Initiative
- **KNUST**: Kwame Nkrumah University of Science and Technology
- **MoH**: Ministry of Health
- **MI**: Myocardial Infarction
- **NCD**: Non-Communicable Disease
- **NHIA**: National Health Insurance Authority
- **NICE**: National Institute for Health and Care Excellence
- **NHIS**: National Health Insurance Scheme
- **NHS:** National Health Services
- **NHSO**: National Health Security Office (Thailand)
- **OOP**: Out of Pocket
- **PEN**: Package of Essential Non-communicable Diseases
- **SEARO**: South East Asia Regional Office (WHO)
- **STG**: Standard Treatment Guideline
- **TWG**: Technical Working Group
- **TZD**: Thiazides/Thiazides like diuretics
- **T2D**: Type II Diabetes Mellitus
- **UHC**: Universal Health Coverage
- **UNDP**: United Nations Development Programme
- **WHA**: World Health Assembly
- **WHO**: World Health Organization

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1 Executive Summary

A case for further investment in health cannot be made unless systems are in place to ensure good value for money for every Cedi spent. Identifying in an evidence informed way, opportunities for releasing resources for reinvestment to expand coverage whilst ensuring health outcomes remain the same or improve, is a powerful argument for more and better spending on health in Ghana. This report goes some way towards making the case for an HTA mechanism for strengthening the handle of the Ghanaian authorities over its own budget through tackling a specific case of high spending and high burden area, namely hypertension management. Using Ghanaian data and making all assumptions explicit, this analysis points to areas for improved spending, quantifies potential savings and health gains from reallocation and makes a case for an institutionalised approach to HTA in Ghana, as an important tool for transitioning away from aid and move towards sustainable and affordable Universal Healthcare Coverage.

A technical working group comprised of UK and Ghanaian members adapted an existing Excel model, initially developed for the 2006 update of the NICE clinical guidelines on hypertension. This model compared the cost-effectiveness of the four main classes of antihypertensive drugs (ACE inhibitors/ ARBs, beta-blockers (BB), calcium channel blockers (CCBs), thiazide-like diuretics (TZD), and no intervention). The model predicted that in the Ghanaian context, diuretics and CCBs would be more effective and less expensive than other drug classes. Compared with no treatment, **diuretics** cost an additional **GH¢ 642** per DALY avoided, while the incremental cost per DALY avoided for **CCBs** compared with diuretics was much higher at **GH¢ 32,482**.

Furthermore, in order to enhance the policy relevance and usefulness of the model to Ghanaian policy makers, the report goes through a number of policy scenarios. The extent to which there are policy levers for acting on them (e.g. drug price), and whether the model could offer credible analytics to back such policy actions were discussed.

The results show substantial potential for cost savings, if such policy scenarios could be implemented. For instance, a **10% reduction in mean drug cost** would yield the greatest savings, over **GH¢ 25 million** over the first five years. This was followed by **10% prescription shift from CCB to TZD**, with five-year savings of over **GH¢ 18 million**, and **10% shift from ACEi/ARB/BB to TZD** yielding 5-year savings of over **GH¢ 5 million**, not to mention the addition of health benefits following such shift.

Finally, the findings of this report consider the reallocation of savings from these cost saving scenarios to improve **health benefits** and **coverage** in Ghana. For example, **providing diuretic treatment to all patients** with diagnosed but untreated hypertension would only cost a**n extra GH¢ 5.9 million** over five years, only using a fraction of the savings of above scenarios, as well as yielding a net gain of avoiding over **46,000 extra DALYs**.

2 Background

The Global Health and Development group (GHD) at Imperial College London (formerly NICE International) has worked with the Ghanaian authorities under the leadership of the country's Ministry of Health (MoH) for a number of years. They have received support from the UK's Department for International Development (DFID) and The Rockefeller Foundation [1].

Since the last visit in April 2016 (see Appendix A for a summary), the UK team has been working with the Ghanaian partners to identify opportunities for application of a more streamlined Health Technology Assessment (HTA) approach to the policy challenges faced by the country. The goal is to maximise heath gains from current resources through enhancing Ghana's strategic capabilities for better commissioning (purchasing) of commodities and services, to guide the selection of new technologies for investment and to optimise the use of existing ones. Informed resource allocation is an indispensable function for a country in the process of transition from international development aid. To demonstrate this with a specific case study, GHD and the Southampton HTA Centre collaborated with a Ghanaian Technical Working Group to develop a model for the cost-effective management of hypertension in Ghana.

With the release of Health Intervention and Technology Assessment (HITA) Resolution of the 67th World Health Assembly (WHA) in 2014 [2], HTA has gained momentum as a policy tool (see for example *Priority-setting for achieving universal health coverage* discussion in the World Health Organisation (WHO) Bulletin [3], and *Briefing note on Health Intervention and Technology Assessments in support of universal health coverage in SEAR* for an example from WHO's South East Asia Regional Office [4]).

This report summarises the technical and data aspects of the Ghana hypertension model, compares it's characteristics to that of the Reference Case for economic evaluation and sets out specific policy angles of interest to Ghanaian policy makers, including the potential linkage between HTA and reimbursement [5]. Finally, it sets out a vision for joint work over the next 2-3 years, based on the country's priorities and commitment to building the needed capacities for effectively using economic and clinical evidence of comparative effectiveness to inform spending decisions. A summary of the previous visit and related analyses, agendas and presentation material are all offered in appendices at the end of this report.

At a time when Ghana is transitioning away from aid whilst striving to expand and ensure the financial sustainability of its health insurance scheme, transparency and accountability become even more important, especially when it comes to strategic investment decisions in healthcare. Building on strong institutional structures for multi-stakeholder engagement, evidence informed policy such as the Essential Medicines List and the Standard Treatment Guidelines (STGs), the recently formed HTA Working Group, and existing academic groups with a track record in the field of HTA at Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi and University of Ghana School of Public Health, Accra. This is an opportunity to help build a Ghanaian HTA system to better control escalating costs and inform future investment and disinvestment decisions.

HTA offers a framework for decision making through processes engaging multi-stakeholders and an interdisciplinary approach, which aims to incorporate locally relevant evidence and values to drive better decisions. Nonetheless, HTA relies heavily on implementation levers such as provider payment, contracting, patient and professional education and strong regulation to make a difference.

3 The Workshops

A series of workshops and official meetings were held throughout the week-long visit in April 2016. Below we sum up the discussions and conclusions.

3.1 Technical Working Group at the National Health Insurance Authority (NHIA)

A roundtable was held at the NHIA, with participation from senior officials from various departments, including Quality Assurance, Accounts, Provider Payment, the Chief Pharmacist's Office of MoH, Ghana National Drugs Programme, WHO, and clinicians from the Korle Bu Teaching Hospital. Many of the above were members of the HTA Technical Working Group (TWG) (see Annex C: Members of the HTA Technical Working Group).

The purpose was to recap on progress so far with the hypertension case study, discuss the quality and relevance of data sources and identify new data as required, check the realism and acceptability of assumptions, and to set out policy makers' decision needs so that the model can be adapted to support such decisions in the context of NHIA and the MoH. The Ghanaian Reference Case and next steps in our partnership were also on the agenda.

The discussants raised issues related to the importance of hypertension as a driver of costs and burden in Ghana (see Figure 1 below for ranking of mortality drivers and how they have changed over past decade [6]). The importance of comorbidities and adverse effects was emphasised, including diabetes, which has a higher incidence with certain classes of anti-hypertensives. The point was made by Professor Lord that this is a blueprint model which can help train and build local capacity, not only for hypertension but also for other non-communicable diseases such as cancer, where drug toxicity is a major concern. Methods of modelling are somewhat different for infectious diseases, because of the need to account for transmission within the population, but the processes for model development, validation and use to inform decision-making are similar.

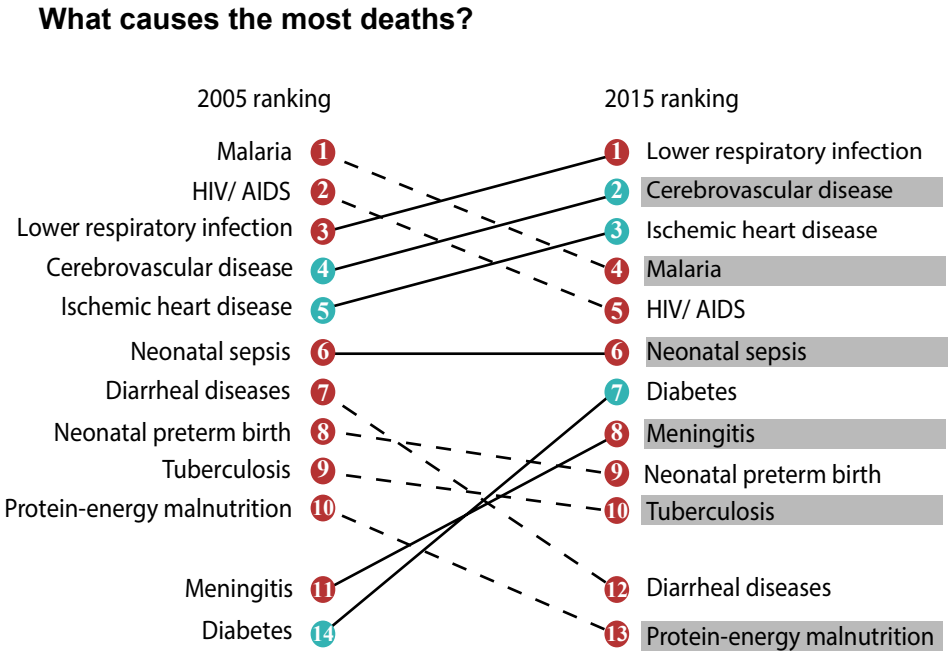

Figure 1. Top 10 causes of death by rate in 2015 and change from 2005-2015 [6]

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Early model results were discussed, demonstrating trade-offs between drug classes (e.g. diuretics being cheaper but leading to higher rates of diabetes than CCBs). Combination treatments are currently excluded from the model, but this was identified as a priority to include in potential future studies. Although not mentioned in the 2010 STGs, there is anecdotal evidence that current advice from MOH supports CCB or a diuretic as first line treatment and this may be reflected in the new Ghanaian STGs currently in preparation.

The perspective for costing was discussed. The model in its current format only includes NHIA costs (taking a relatively narrow perspective). However, it was noted that other perspectives could also be added in future studies. Out of Pocket (OOP) payments, informal caring and productivity costs are very important for a country like Ghana which is *en route* to Universal Health Coverage (UHC), so that authorities can show to the government and population how potentially catastrophic costs to families and socially-damaging impacts on productivity can be averted.

It was also noted that assumptions regarding the percentage of people covered by insurance and accessing treatment drive total expenditure (i.e. under UHC more people would be treated, driving costs up). The potential for using the NHIA's purchasing power to reduce prices was also highlighted, and it was agreed that this should be a priority for testing through simple sensitivity analysis.

The potential value of a polypill was identified as a topic requiring further research. A polypill is a fixed-dose combination (FDC) medication that combines multiple active pharmaceutical ingredients. For example, a cardiovascular polypill including aspirin, lisinopril, hydrochlorothiazide and simvastatin has been proposed [7, 8].

Several areas for improving the model were discussed, including extending the range of policy options that could be compared. For example, the relative priority of improved case finding, versus treatment for more people with known hypertension, versus enhanced intensity of treatment for those already on treatment. In addition, primary prevention policies might also be considered. For example, targeted education and population-level interventions to reduce the use of salt and promote healthy behaviours (e.g. physical exercise).

Information on current prevalence and levels of awareness, treatment and control of hypertension from the 2014 Ghana Demographic and Health Survey (DHS) was discussed [9]. At the time of the survey, over 20% of those aged 35 to 49 suffered from hypertension: defined as raised blood pressure (systolic of 140 mmHg or more and/or diastolic of 90 mmHg or more) or controlled blood pressure on medication. Of those with hypertension, over 60% of women and 80% of men reported that they were not aware of their condition (see Figure 2): worse than might be expected under the 'rule of halves' [9]. Of those reporting known hypertension, most were on treatment, but about half of those on treatment still had high blood pressure. This suggests that there is considerable potential for health improvement if feasible and affordable methods for primary prevention, case finding and effective treatment (secondary prevention) could be implemented.

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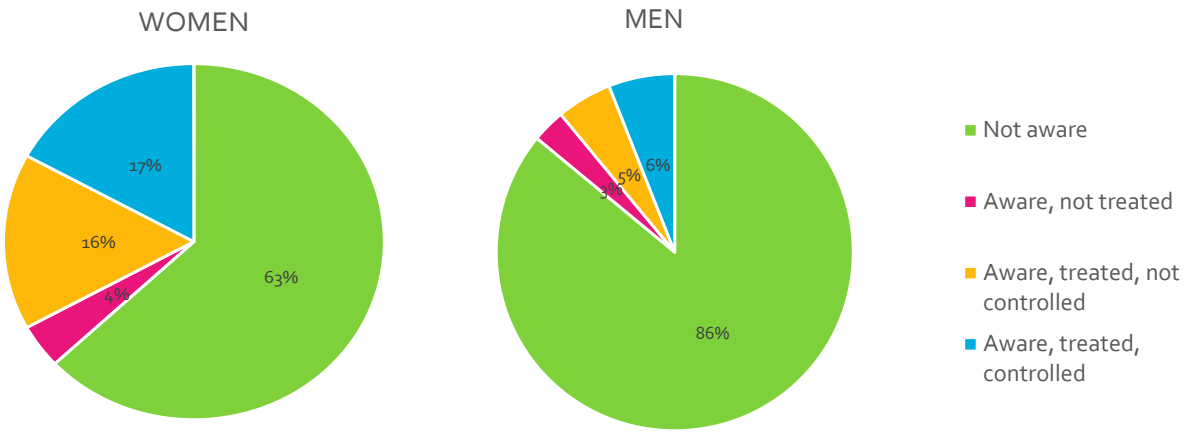

Figure 2. Distribution of hypertension cohorts among both genders

It was agreed that the model should place more emphasis on budget impact, including splitting costs across different payers. This is essential information, alongside estimates of long-term cost-effectiveness, for decision makers to assess the feasibility of policy options under financial constraints.

Another objective for policy makers might be the equity impact of interventions. The model currently provides average estimates for the whole of Ghana, but it would be possible to stratify results by geographical or socioeconomic subgroups to inform decisions over whether and how to target interventions. Previously, Non Communicable Diseases (NCDs) and hypertension have been viewed as only a problem for more affluent and urban communities, but increasingly they also affect the poor in rural populations. The 2014 DHS estimated prevalence of hypertension at 9% in rural areas compared with 16% in urban areas; and prevalence in the lowest wealth quintile was 7% compared with 18% in the highest wealth quintile. The remaining differences are unlikely to be explained by under ascertainment in poorer and rural areas as the figures are based on a population sample and coverage of blood pressure measurement was high (over 99.6%) and did not vary by region, urban/rural residence, level of education or wealth quintile [9].

Research recommendations

Several recommendations for further research and targeted data collection were made, including:

- Carrying out a meta-analysis of all the Ghanaian epidemiological data including but not limited to the 2014 DHS [9].
- Establishing the incidence of Cardiovascualr Disease (CVD) events, hypertension and Type 2 Diabetes (T2D) – through a prospective cohort study, although the expense of such work was also highlighted.
- Meta-analysis to estimate combination treatment effects – from international literature [10].
- Establishing current prescribing patterns – e.g. through interrogating National Health Insurance Scheme (NHIS) data.
- Better specification of resource use per person and percentage of people who get treated – the importance of which can be tested through simple sensitivity analysis.
- Establishing unit cost data for commonly used drugs – through NHIS and Essential Medicines List (EML).

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Policy weaknesses and possible levers for implementation

- Leverage electronic and mobile technology for changing behaviour. E.g. design a mobile application and prescribing software listing approved medicines to reduce OOP and better communicate to patients and families when drugs are not approved by the NHIA and for which they should not be spending OOP. Consider the Thai National Health Security Office (NHSO) system as a model.
- Further improve approach to price negotiations including guaranteed volumes to reduce unit costs. Build on experiences of other HTA agencies such as PHARMAC in New Zealand and Australia's PBAC. Address through innovative payment mechanisms delays in payment and volatility of currency.
- Address supply chain inefficiencies including a single framework contract for procurement encouraging consolidation of a highly fragmented market of local manufacturers to reduce product costs.
- Enhance capacity for technical and policy analysis to inform and implement evidence-based prioritisation and purchasing.

3.2 Policy and Technical Roundtable at the Ministry of Health (MoH)

Having met the Chief Director of the MoH, another meeting was set with the NHIA and additional colleagues from the MoH, to discuss in further detail the model inputs and opportunities for improvement, as well as the specific policy recommendations, which the analysis can underpin with a view to strengthening the sustainability and accountability of UHC in Ghana.

The discussion touched on policy priorities – e.g. the position of kidney disease as a growing burden for Ghana – and how to amend the model to make it most useful to the Ghanaian policy makers faced with growing costs of dialysis (see for example Teerawattananon *et al* for a summary of experiences across seven Asian countries). It was agreed that dialysis and prevention of end stage renal disease may be a high priority topic for a second HTA pilot.

The sources of cost data were questioned as the data in the previous version of the model were from 2007 – it was agreed to update these costs. Issues of ex-factory price, procurement, supply chain inefficiencies, and add-on costs are all important, as prices of drugs are a major driver of overall costs. Indeed, a major outlier driving overall treatment costs was non-proprietary Nifedipine 10mg capsules, which are costing the NHIS nearly GH¢ 900 per patient per year, compared with about GH¢ 150 for Nifedipine 20mg slow release tablets or about GH¢ 100 for Amlodipine, in the same class.

Prescribing practices of junior doctors were discussed and the idea of running health economics or STG classes for undergraduates was raised as an option. Prescribing generics versus branded and the role of junior doctors, as well as consultants so that patients do not feel obliged to pay out of pocket for the more expensive product, were all highlighted as major deficiencies of the system. Indeed, Continuing Professional Development (CPD), as well as undergraduate training, and reaching doctors through the August Health Fiesta were all proposed as means of increasing the number of cost conscious professionals at all levels across Ghana.

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The role of the Food and Drug Authority (FDA) and ensuring quality of generics through licensing and post market surveillance, as well as a competitive generics market were also identified as policy priorities for improving effective spending on drugs. There is a lot to discuss regarding the linkages between regulation and a viable generics market.

3.3 Model Refinement: Data Retrieval and Budget Impact Calculations at NHIA

We spent the following day going through the model with the technical team, offering hands on training and passing the model over to the technical group. In Excel format, this model is easy to use with extensive annotations explaining the underpinning assumptions and is fully executable. In addition, cost data and resource use data were updated and confirmed, and policy scenarios were presented during the 2017 April Health Summit, and were rehearsed for their relevance to key policy questions in Ghana.

Budget impact analysis was presented and the potential for cost-saving through use of less expensive formulations (e.g. 20mg vs. 10 mg formulations for CCBs) or price negotiation were demonstrated. A comparison was drawn with UK prices for CCBs, where some branded generics have a lower price than that listed by the NHIA. The latter is derived by market surveys carried out by the Ghanaian authorities, is not weighted by volume and can be driven by individual outlier products.

The budget impact analysis offers estimates of total savings from possible shifts in price or utilisation of different antihypertensive drugs, formulations, or brands. It illustrates how these savings could be channelled to achieve extra coverage or better control for the population.

For budget impact calculations, it is necessary to estimate the numbers of people who are currently treated for hypertension, and how this might change under alternative policy scenarios. Estimates of prevalence and rates of treatment were presented, based on the 2014 Ghanaian DHS (see Table 1).

	Age	Treated	Not aware (NA)			Aware but not treated (ANT)			Treated but not controlled (TNC)			
	group	Controlled	Mild	Moderate	Severe	Mild	Moderate	Severe	Mild	Moderate	Severe	
MEN	25	45,989	103,785	13,090	6,545	3,620	457	228	6,034	761	381	180,890
	35	34,564	138,737	48,176	10,148	4,840	1,681	354	8,066	2,801	590	249,956
	45	15,902	126,221	45,591	25,300	4,403	1,590	883	7,338	2,651	1,471	231,350
	55	30,136	90,505	55,142	28,170	3,157	1,924	983	5,262	3,206	1,638	220,123
	65	20,052	60,220	36,690	18,744	2,101	1,280	654	3,501	2,133	1,090	146,465
	75	24,872	74,698	45,511	23,250	2,606	1,588	811	4,343	2,646	1,352	181,677
WOMEN	25	37,275	53,933	13,262	8,841	3,424	842	561	13,697	3,368	2,245	137,450
	35	59,120	100,194	25,333	19,897	6,361	1,608	1,263	25,446	6,434	5,053	250,709
	45	74,825	122,537	48,152	30,558	7,780	3,057	1,940	31,121	12,229	7,761	339,960
	55	63,555	104,081	40,899	25,955	6,608	2,597	1,648	26,433	10,387	6,592	288,756
	65	46,922	76,842	30,195	19,163	4,879	1,917	1,217	19,515	7,669	4,867	213,185
	75	75,182	123,122	48,382	30,704	7,817	3,072	1,949	31,269	12,287	7,798	341,582
		528,394	1,174,875	450,423	247,276	57,597	21,612	12,491	182,026	66,572	40,836	2,782,103

Table 1. Prevalence of hypertension in Ghana by age, sex, severity and treatment status

There are an estimated **2.8 million** Ghanaians with hypertension, of whom about **a fifth** (half a million) have their blood pressure effectively controlled with medication. Of those with severe

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hypertension, who are at the greatest risk of an adverse event such as a stroke or myocardial infarction (MI), **82% are unaware of their condition** and **a further 4% are not receiving any treatment**. Shifting these statistics, especially for the severe group, would prevent future events including costly hospitalisations, possibly saving the NHIA resources to be redeployed elsewhere (e.g. to increase detection rates in the community). NHIA officials were most interested in the "**cost of inaction**" especially in the cohort of **300,604 people with severe hypertension** who are currently undiagnosed, untreated, or inadequately treated.

Policy scenarios to be modelled included:

- Savings resulting from changing prescribing practices towards the least expensive option and/or reducing drug prices within and across classes.
- Costs and savings/Disability Adjusted Life Years (DALYs) averted of investing in "shifting the pie" including improving rates of diagnosis, treatment and effective control amongst the large percentage of the Ghanaian population currently undiagnosed, untreated or with inadequately controlled blood pressure.
- Costs and benefits from primary prevention ("shrinking the pie"), for example educational interventions to reduce salt intake amongst the population.
- Estimation of the budget impact and health improvement, if the whole of the population were to be covered by NHIS (as opposed to ~40%), to illustrate the impact of achieving UHC.

Discussions regarding the percentage of utilisation (**active utilisation**) of services from the NHIA perspective concluded that a ceiling of the current NHIS coverage at 42% with an average utilisation rate of 80% for those insured would be appropriate [11]. Possible sources of data on resource use and clinical management were discussed (e.g. how many repeat visits per annum following a stroke would a patient have on average across facilities in Ghana?). Current estimates were based on the NHIA Diagnosies Related Group schedule data and clinical judgements.

Key priorities and parting thoughts included:

- "Better research and data collection for Ghana" – including for example routinely collected data for hypertension in all community centres – and "better use of the data we have".
- Building capacity for using the Excel model when the UK team departs.
- More work is needed on HTA institutionalisation including deciding on its structures, as well as technical and decision making resources.
- "If done well it will save lives and will save the nation money" – a push to do more including more comorbidities and other diseases.
- "Sustained capacity building for HTA for Ghana" – an urgent need for sustainability in transitioning from aid.
- Use HTA approach "…to inform service tariffs and medicines list for NHI"
- "Wide stakeholder engagement from the lowest levels…civil society"
- An observation of "varied interests based on institutions which need to converge…"
- A call for "MoH to institutionalise HTA so that every institution can use the tool":
    - NHIA for efficiency, cost control, and quality.

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- Academia for evidence synthesis and analysis.
- Providers for improving quality of care.
- Pharmaceutical companies to improve their business.

- "We must use HTA to inform policy decisions at the MoH level"

Though **institutional structures** were not discussed in detail, the need for a technical working group and perhaps a higher-level committee to pass on recommendations to the Minister, was highlighted (see Figure 3).

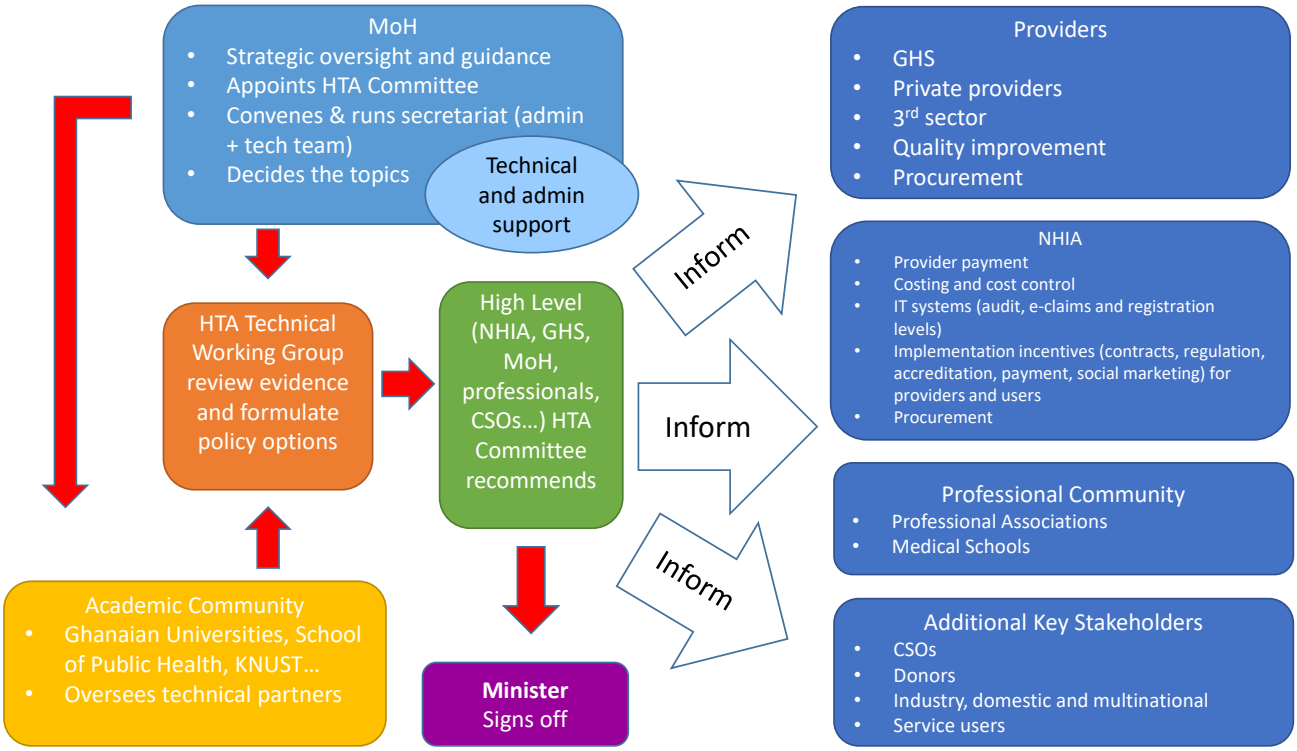

Figure 3. Potential Institutional structure for HTA in Ghana

4 Additional Meetings

Two brief high-level meetings were held with the Chief Director of the MoH who reiterated the Ministry's on-going support for this work and the newly appointed CEO of the NHIA, who again asked for the results of this exercise to inform the NHIA's decisions.

5 Case Study: Ghana Hypertension Model

5.1 Background

The technical working group adapted an existing Excel model, initially developed for the 2006 update of the National Institute for Health and Care Excellence (NICE) clinical guideline on hypertension [12]. This model compared the cost-effectiveness of the four main classes of antihypertensive drugs (ACE inhibitors/ARBs, beta-blockers (BB), calcium channel blockers and thiazide-like diuretics) and no intervention, for initial treatment of primary hypertension in UK patients without CVD, diabetes or heart failure, and excluding pregnant women. The NICE model was first modified for Ghana during the April 2016 Accra workshop, and further adaptations were made before and during the 2017 visit.

A short summary of the revised model and results is provided below. More detail is provided in Appendix D and E.

5.2 Model Approach and Structure

The model estimates results for a series of subgroups defined by age groups, sex and levels of blood pressure. The numbers of people in each subgroup reflect the makeup of the population in Ghana. It is assumed that members of each subgroup start with no history of cardiovascular disease, diabetes or heart failure. Each year, there is a risk that patients will experience a first stroke or coronary event, onset of diabetes or heart failure, or that they may die of hypertension-related or other causes. Patients who survive one adverse event are then at higher risk of another.

The model tracks the numbers of people in each subgroup who are likely to experience the adverse events over their lifetimes (up to age 90), under six treatment options: no antihypertensive medication, ACEi, ARB, BB, CCB or TZD. With medication, the risks of adverse events are modified according to evidence from the international trial literature [13-15].

Health outcomes (life years and DALYs) and healthcare costs are estimated for each subgroup under each treatment option. Age weights are applied in the DALY calculations, and years of life lost estimated with respect to standard life expectancy. As a first step, costs are estimated from an NHIS perspective (for simplicity), and include the cost of care and treatment following adverse events as well as the cost of antihypertensive medications. Costs and DALYs are discounted at an annual rate of 3%. In addition to long-term estimates of cost-effectiveness (incremental cost per DALY avoided), budget impacts of alternative treatment scenarios over five years are presented. Results can be calculated for the whole hypertensive population, or for particular groups: for example, just for patients who are currently receiving treatment.

5.3 Data Sources for Model Parameters

Sources of data were based on local data where possible:

- **Prevalence of hypertension** for the Ghanaian population, stratified by age, sex and severity of hypertension [16, 17]. Figures were further broken down by treatment status (not diagnosed, diagnosed but not treated, treated but not controlled or treated and controlled).
- **Mortality rates** for Ghana were taken from a WHO estimated life table [18].

Case Study: Ghana Hypertension Model

- **Incidence of major adverse events** (stroke, Coronary Heart Disease (CHD), diabetes and heart failure) by age, sex and severity of hypertension. Estimates were not available from a Ghanaian (or other West African) population cohort, so international data were used [13, 19-21].
- **Effectiveness of antihypertensive drugs** on incidence of adverse events in a black African population [13-15].
- Current **NHIS drug prices and costs for health services** [22-26].
- **Utilisation of services** following adverse events were based on NHIS protocols and expert opinion.
- **DALYs** were added as the primary measure of health impact. Disability weights were from the 2004 Global Burden of Disease (GBD) study, because more recent summary estimates are not available for the conditions of interest (stroke, CHD, diabetes and heart failure) [27, 28].

A detailed description of the model parameters is provided in **Appendix D**. Probability distributions were assigned to uncertain input parameters to enable probabilistic sensitivity analysis.

5.4 Comparative Cost-effectiveness of Drug Classes

The model predicted that in the Ghanaian context, diuretics and CCBs would be 'dominant': providing better health outcomes (more years of life and fewer DALYs) at a lower cost to the NHIS than the other drug classes. This result was driven in particular by a greater reduction in stroke incidence. CCBs in particular were estimated to give greater protection against stroke and new-onset diabetes than diuretics, although they are more expensive and are associated with a greater incidence of heart failure.

Compared with no treatment, **diuretics** cost an additional **GH¢ 642 per DALY** avoided. The incremental cost per DALY avoided for **CCBs** compared with diuretics was much higher at **GH¢ 32,482**. This figure was highly sensitive to assumptions about the price of CCB formulation. If the lowest price CCB is used (generic Amlodipine 10mg tablet, 52 GH¢ per year), rather than the NHIS median (399 GH¢ per year), the incremental cost effectiveness ratio (ICER) for CCB vs. diuretic falls to GH¢ 2,881 per DALY avoided. Conversely, the most expensive CCB covered by the NHIS (branded amlodipine 5mg, at 2,738 GH¢ per year) has an ICER of over GH¢ 200,000 per DALY avoided.

5.5 Policy Scenarios

In order to enhance the policy relevance and usefulness of the model to Ghanaian policy makers, a number of policy scenarios were rehearsed, the extent to which there are policy levers for acting on them (e.g. drug price), and whether the model could offer credible analytics to back such policy action were discussed. We tested some scenarios to illustrate the potential for improving health outcomes for the population within existing resources. The options considered include cost-saving possibilities (lower prices or shifting from more expensive pharmaceutical options to less expensive ones when clinically appropriate), with a view to reinvesting the resulting savings to increasing coverage and/or reducing the number of undiagnosed, untreated or inadequately treated patients.

Case Study: Ghana Hypertension Model

A. Cost saving scenarios:

The following scenarios (see Table 2) were modelled in the cohort of 343,488 patients covered by the NHIS (assuming 42% coverage within population [11]) who are estimated to be currently receiving antihypertensive medication:

1. Price adjustments and negotiations (e.g. 10% reduction in mean drug cost).
2. Interventions to change prescribing practice to increase use of less expensive and more effective drugs (e.g. an assumed 10% reduction in the number of patients prescribed ACEi/ARB/ BB with switch to diuretics).
3. Interventions to change prescribing practice to increase use of better value drugs (e.g. reduction in CCB with switch to diuretics).

Scenario	Patients changing drugs	DALYs avoided	Lifetime cost to NHIS, GH₵ millions	Budget impact (vs. current practice), GH₵ millions					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total 1-5
1) 10% cut in mean drug prices	0	0	-93.7	-3.2	-6.1	-5.7	-5.4	-5.1	-25.5
2) 10% shift from ACEi/ ARB/ BB to TZD	6,050	1,558	-19.1	-0.7	-1.3	-1.2	-1.1	-1.1	-5.4
3) 10% shift from CCB to TZD	13,033	-2,089	-67.9	-2.3	-4.4	-4.1	-3.9	-3.7	-18.4

Table 2. Cost saving scenarios for patients currently treated under the NHIS

The results show substantial potential for cost savings, if such changes could be implemented. **Scenario 1** (10% reduction in mean drug cost) would yield the greatest savings, over **GH¢ 25 million** over the first five years. This was followed by **Scenario 3** (10% shift from CCB to TZD) with five-year savings of over **GH¢ 18 million**, although this would be accompanied by a slight deterioration in health outcomes. In contrast, **Scenario 2** (10% shift from ACEi/ARB/BB to TZD) is a win-win: yielding 5-year savings of about **GH¢ 5 million** in addition to health benefits.

It is important to emphasise that these results are illustrative, but they do highlight how some relatively modest changes to current practice might yield significant savings. The model demonstrates the value of antihypertensive drugs classes versus their costs, therefore giving the government evidence-based negotiation levers that could potentially be used to achieve better prices.

The results could also be used to underpin recommendations for more efficient prescribing behaviour that takes value and costs into consideration, a behaviour that can be easily enforced within the premise of reimbursement terms of the NHIA. This is specifically relevant to prescribing the least expensive drugs within the same class, or prescribing of the effective, but relatively less expensive class of drugs (TZD) as first line of management for new cases. The challenge of mandating a policy of single or specific dual therapy (e.g. CCB and/or diuretic to start [29]) was discussed, and of course for some patients there are other compelling reasons for use of BBs or ACE inhibitors. MoH officials confirmed that a direction for monotherapy with a specific first line drug is now with NHIA which is passing it on

to prescribers as a condition for reimbursement, showing commitment and potential for implementing cost-effective policies in Ghana.

B. Health improving scenarios:

Any generated savings would offer an opportunity to further strengthen NHIA functions in Ghana. Within the field of hypertension, savings could be used to fund various health improving scenarios. For example, suppose that GH¢ 18 million could be released over five years by switching 10% of treated patients from a CCB to TZD (Scenario 3). Although this would be associated with an increase of around 2,000 DALYs, there would still be a net health improvement if the savings were to be spent in more efficient ways. For example:

4. Extending NHIS coverage to enable more patients to benefit (e.g. to provide diuretic treatment to all patients with diagnosed but untreated hypertension would only cost an extra GH¢ 5.9 million over five years, but would yield a gain of over 48,000 DALYs avoided, a net gain of about 46,000 DALYs avoided.
5. A programme of active case finding, to find and offer treatment to say 5% of over 40's, who have not been diagnosed with hypertension. This approach is illustrated in Table 3 using estimates of costs and screening uptake and yield from a trial of community pharmacy-based screening in Ghana [30]. Although not as efficient as Scenario 4, this option would still offer a net health gain. The additional cost would be GH¢ 10.6 million over five years, and over 5,300 DALYs would be avoided (a gain of around 3,300 DALYs avoided).

Other possible scenarios that could be evaluated in future work include:

- Primary prevention approaches, such as a community-based educational programme to reduce use of salt in the diet [31, 32].
- Combination antihypertensive therapy for patients who do not achieve adequate blood pressure control on a single drug [10].
- Combination therapy including statin and antihypertensives, with or without aspirin, for prevention of cardiovascular disease ('polypill') [7].

Scenario	Patients changing drugs	DALYs avoided	Lifetime cost to NHIS, GH₵ millions	Budget impact (vs. current practice), GH₵ millions					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total 1-5
4) Prescribe TZD to all patients diagnosed with hypertension who are not currently treated	91,701	48,063	21.6	0.6	1.5	1.4	1.3	1.2	5.8
5) Offer screening to 5% of over 40's without a diagnosis of hypertension	248,752 invited for screen, 11,715 offered TZD	5,359	12.14	10.00	0.17	0.16	0.14	0.13	10.60

Table 3. Health Improving Scenarios

Case Study: Ghana Hypertension Model

5.6 Dissemination Plan

Dissemination plans for the model results were discussed and the following was proposed/ implemented:

- During the April Health Summit in Kumasi (19th -21st of April 2017) slide sets as well as an executable model were presented. One UK expert was sent for the event to work on presenting results with the Ghanaian partners during the summit. Additional material regarding a roadmap for HTA and the Reference Case will also be made available and a consultant is being recruited to work with MoH and iDSI on a strategic plan for HTA institutionalization.
- Exploring using HTA modules for CPD events to raise clinician awareness on costs. The August Health Fiesta was suggested as a possible opportunity for this.
- Maintain high level of engagement with multiple sources of support (see below on next steps).
- Publishing a joint paper in a peer reviewed journal of the experience, technical, and policy aspects of the work done in Ghana.
- Participate in Liverpool Health Services Research Summit in 2018 and aim to include Ghana as a showcase in a satellite event.
- Build Ghana into iDSI 3 for DFID Technical Assistance in priority setting for UHC and as a model for countries transitioning away from aid.

6 Next HTA Topic in Ghana: What Should We Be Looking At?

A number of topics were highlighted including Diabetes Mellitus, especially (T2D); cancer; dialysis and end stage kidney disease; comorbidities with multiple NCDs and also NCDs and infectious disease; prevention packages such as WHO's Package of Essential Non-communicable (PEN) Disease Interventions, and also population level interventions such as taxation and behavioural changing education campaigns for reducing salt and sugar consumption. Mental health which is nominally under MoH coverage but not part of NHIS, may be another priority given that it accounts for 10% of the burden of disease and most of spending is OOP. Devices were also highlighted as a priority (see Figure 4 for schematic for potential topics).

Topic prioritisation processes across different countries were also discussed including the criteria used in England and Thailand.

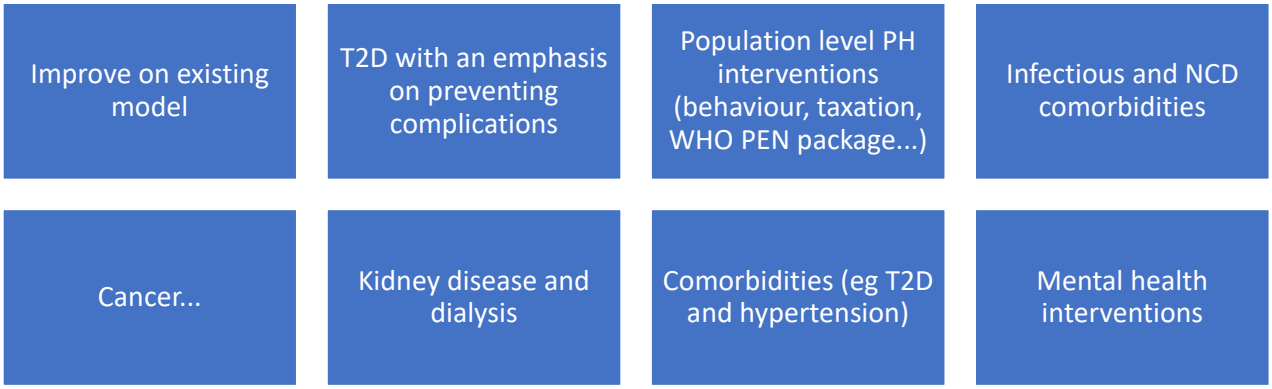

Figure 4. Schematic for Potential Topics

7 HTA and Reimbursement Policy in Ghana

HTA can be used to inform decisions on pricing of commodities, including pharmaceutical products and devices as examples from Thailand and South Korea demonstrate. It can also be used to inform decisions on reimbursing services through care packages/clinical pathways as shown in the cases of China and the English National Health Services (NHS).

The slide deck attached below sets out such examples as well as the informational and other structural and political requirements of HTA informed purchasing decisions from a wide range of countries. As strategic purchasing is increasingly promoted by development partners and with a growing interest on the part of national governments and insurance authorities, the role of HTA in informing decisions on pricing of products and services cannot be overlooked.

Discussions during the field visit week highlighted the importance in controlling ex-factory and transaction prices especially as the UK's NHS seems to be getting a better price for some branded generics than Ghana. Managing prescribing in terms of first and second line treatments and starting with the cheapest in class can make a major difference in spending. Quality indicators for certain services (e.g. establishing registries for people with high blood pressure or ensuring prescriptions are filled for patients with CVD events on discharge), are process measures shown to improve outcomes. Pay for performance schemes could encourage such activities. Many countries have used HTA to inform reimbursement decisions and Ghana can do the same in a targeted and incremental fashion.

More information on the slide deck is available here.

8 A Joint Activity Programme for 2017-2020

We propose a diversified approach to funding our on-going joint activities between the UK and Ghana including funding from Rockefeller and the UK's DFID for technical assistance, United Nations Development Programme (UNDP) and PATH for in country support, as well as UK Research Council funding to strengthen the links with Universities in Ghana and ensure capacity is in place to drive the analytics in response to NHIA and MoH policy questions (See Figure 5).

In addition to supporting the April Health summit in Kumasi, we would like to publish joint work together, arrange for joint workshops, arrange for conference presentations (e.g. HSR Liverpool 2018), provide training events and exchanges, and also plan for a new pilot for HTA in a priority area for the Ghanaian MoH.

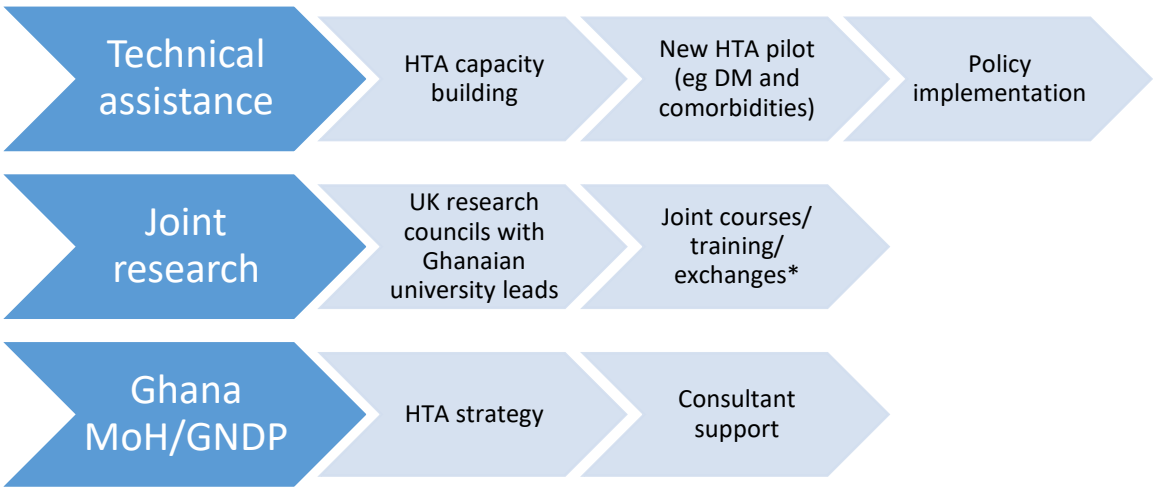

Figure 5. A schematic for Joint activity programme for 2017-2020

Appendix A: The April 2016 Visit – Report Findings and Recommendations

Executive Summary

Ghana has a unique opportunity to: establish a well-coordinated HTA/priority setting process building on existing structures and technical capabilities, and to introduce a formal process for assessing the benefits and costs of selecting alternative technologies in devising its Health Benefits Package.

A workshop held in April 2016 with a multi stakeholder group confirmed the interest and willingness to move forward with practical steps on HTA. A model using cost-effectiveness analysis for hypertension medicines in Ghana was developed with a Ghanaian technical working group. The model is based on the expressed wish of the Ghanaian authorities to concentrate on priority NCDs such as cardiovascular disease and diabetes.

The health economics model on antihypertensive drugs in Ghana, using local data and context sensitive assumption, could inform policy decisions in managing hypertension. In its early version, the analysis confirms the recommendations in the latest national STGs on management of hypertension, and could help further by answering the question of whether Ghana should invest in CCBs rather than diuretics, and if so, for which patients. The model may also help further inform and indeed strengthen the STGs' negative recommendations against the use of other drug classes such as ACE inhibitors or beta blockers, as first line medications for essential hypertension unless there is compelling indication: for example, heart failure. This would require further subgroup analyses as well as quality checks and agreement on cost per DALY threshold.

Discussions with relevant stakeholders confirmed the need to strengthen priority setting in Ghana and commitment to move ahead with HTA, especially in the light of the NHIS review with an emphasis on quality and affordability. HTA can be one of the tools for the MoH and NHIA to help manage escalating costs by better targeting treatments to the right group of people and perhaps also informing price negotiations and coverage decisions.

A flyer outlining the benefits of HTA for Ghana was circulated at the April Ghana health summit by the government, highlighting the commitment of the authorities to use evidence and analysis to inform their decisions. However, HTA/Priority Setting work will require coordination from the Ministry of Health of all relevant stakeholders, and a concerted effort to build technical and also administrative capacity as well as political and media awareness.

Appendix A: The April 2016 Visit – Report Findings and Recommendations

Recommendations

Ghana has a strong political commitment to UHC, a growing and enthusiastic technical cadre across its universities and the ministry, and a well-established process for making decisions on STGs and EML is being established. Building on these we propose that the Ghanaian authorities:

- Build on and strengthen technical capacity at universities and the MoH, to undertake HTA activities in Ghana to help inform the Health Benefits Package in partnership with international networks such as iDSI and overseas universities with a track record in HTA for informing decisions, such as Southampton University.
- Define an HTA work programme for the next two years, with specific HTA activities and specific products targeting priority areas for Ghana.
- Develop the methods and processes for undertaking HTA in Ghana.
- Develop a roadmap as to how the HTA results will inform resource allocation decisions.
- Designate a core unit to coordinate this work and engage all relevant parties whilst strengthening the existing working group and technical partners, which led on the present project.
- Leverage funding from appropriate sources including own funds and donors to undertake this work, and for technical cooperation with the right institutions to see it through.

Next steps

The international Decision Support Initiative (iDSI), a network of practitioners, academics and policy makers working together towards better decisions for better health is ready, with the backing of the British Department for International Development to bring its full institutional and technical support to Ghana.

What is needed from the Ghanaian side is:

1. Strong political backing.
2. A commitment of dedicated technical and administrative staff on the ground.
3. Access to the best available data to facilitate the analyses.
4. An overall willingness to partner up on an institutional basis with like-minded institutions such as NICE, Southampton and HITAP to work together towards attaining and sustaining UHC.

Appendix A: The April 2016 Visit – Report Findings and Recommendations

Things to do for the cost-effectiveness model:

- Run quality checks on the model coding, data inputs and face validity.
- Complete analysis for key population subgroups (varying age and 10-year CVD, diabetes and CHF risks).
- Conduct sensitivity analysis to assess the robustness of the results to uncertainties over model inputs.
- Use model results to inform decisions about whether NHIA should fund CCBs rather than diuretics for first line uncomplicated essential hypertension. This will require discussion of the clinical validity of the data and assumptions underlying the model, and agreement on an appropriate cost-effective threshold (maximum cost per DALY avoided) to be applied.
- Carry out baseline and costing analyses to assess the potential savings with no harm to health outcomes of switching to most cost-effective practice.

For the STG on hypertension management:

- Consider whether to strengthen National STG recommendations against the use of ACE Inhibitors, Angiotensin II Receptor Blockers (ARBs) or Beta Blockers without other compelling indications.

Appendix B: Agenda of the 2016 Visit and List of Participants

Time	Topic	Lead
9:30	Introductions and plan for the day	All
9:40	Recap on what we did last time: Cost-effectiveness of antihypertensive drugs in Ghana	Joanne Lord
10:00	What next? Options for improvement and extension of the model. What would you like it to do? Discussion	Joanne Lord All
10:30	Overview of model structure	Joanne Lord
11:00	**BREAK**	
11:10	Discussion of data sources	All
12:00	Discussion of outputs and presentation of results	All
12:20	Reminder of iDSI Discussion of reference case. Discussion of relevance for Ghana	Joanne Lord All
12.30	Agree next steps	All
12.45	**LUNCH**	
Mon pm	**Options for further sessions for Technical Working Group** • Work on redefining model structure & options • Work on identifying and selecting data sources • Work on Reference Case for Ghana **Preparation for launch** • Dry run of model launch - new features and links to policy • Q&A with policy makers and researchers	All

Appendix C: HTA Technical Working Group Membership

Name & position	Affiliation
Martha Gyansa-Lutterodt,	MoH Director of Pharmaceutical Services
Edith Gavor	PM, GNDP, MoH (Deputy Director of Pharmaceutical Services)
Brian Asare	Programme Officer, GNDP, MoH
Saviour Yevutsey	MoH, Directorate of Pharmaceutical Services (Deputy Director of Pharmaceutical Services)
Dr Koku Awoonor-Williams	Director, PPMED, Ghana Health Service
Dr Cynthia Bannerman	Deputy Director, Institutional Care Division, quality assurance; GHS
Dr Justice Nonvignon	Senior Lecturer, School of Public Health, College of Health Sciences, University of Ghana
Prof Charles Ansah	Dean, FPPS, KNUST, Kumasi
Prof Francis Ofei	Dean, SMS, UCC and Chair of the Ghana STG
Dr. Marc Dzradosi	STG Review Team
Dr Lydia Dsane-Selby	NHIA
Dr Memuna Tanko	NHIA
Cecilia Senoo	Coalition of NGOs in Health
Dr Emmanuel Odame	MOH Policy Planning Monitoring and Evaluation (PPME) Directorate
Prof Alex Dodoo	College of Health Sciences, UG
Edith Annan	WHO Ghana Office
Ruby Awittor	Ghana Health Service. Ashiama District
Jennifer Manfo	GHS, Ashanti Regional Health Directorate
Dr Adwoa -Benneh	NHIA
Dr Berko Panyin Anto	FPPS, KNUST
George Hedidor	National Drug Resource Information Centre (NDIRC), MOH

Appendix D: Technical Description of Ghana Hypertension Model

Introduction

This appendix describes Version 2.8 of the Ghana Hypertension Model. The model was programmed in Excel by Joanne Lord, initially based on a model developed for the 2006 update of the NICE clinical guideline on hypertension [12], and adapted for Ghana following discussion and agreement of appropriate modelling assumptions and data inputs with the Technical Working Group (see Appendix C) and Kalipso Chalkidou, Francoise Cluzeau and Mohamed Gad. The model is available under a Creative Commons Attribution-Non Commercial-Share Alike license (CC BY-NC-SA 4.0).

Aims and objectives

The aim of the model is to provide a platform to estimate the cost-effectiveness and budget impact of a range of interventions to prevent cardiovascular disease (CVD) through better control of hypertension in the Ghanaian population.

Population and subgroups: The model estimates outcomes for patients with essential hypertension, excluding those with pre-existing CVD, diabetes and pregnant women. 48 subgroups of prevalent cases are defined by: men and women; by 6 ten-year age groups (from 20-29 to 70+); and 4 levels of blood pressure (normal due to effective control with antihypertensive medication, mild, moderate or severe; see Table 4). In addition, patients with raised blood pressure are further divided according to current treatment status (not aware of raised blood pressure; aware but not treated; treated but not controlled). Thus, in total the model includes 120 subgroups of patients.

Blood pressure status	Systolic (mmHg)		Diastolic (mmHg)
Optimal	<120	and	<80
Normal	120-129	or	80-84
High normal	130-139	or	85-89
Level of hypertension			
Grade 1, mild	140-159	or	90-99
Grade 2, moderate	160-179	or	100-109
Grade 3, severe	180+	or	110+

Table 4. Definition of normal, mild, moderate and severe hypertension [17]

Interventions: The model can be used to compare expected outcomes assuming no treatment or monotherapy with one of the 5 main classes of antihypertensive medication:

- Angiotensin Converting Enzyme inhibitors (ACEi).
- Angiotensin Receptor Blockers (ARBs).
- Beta-blockers (BB).
- Calcium Channel Blockers (CCB).
- Thiazide-like diuretics (TZD).

Appendix D: Technical Description of Ghana Hypertension Model

The model does not currently include combination therapy, but this could be added at a later time. By selecting different treatment options for defined proportions of the subgroups, it is possible to estimate the impact of a range of policy options. The analyses presented in this report include four types of policy change:

1. Price reductions for listed drugs: e.g. 10% reduction in mean price of ACEi, ARB, BB and CCB, no change in numbers of patients treated by drug class.

2. Reduced use of less effective/more expensive drugs: e.g. switch 10% of patients currently treated with ACEi, ARB and BB to TZD.

3. Increased use of better value drugs: e.g. switch 10% of patients treated with CCB to TZD.

4. Increased treatment of diagnosed patients: e.g. use of TZD for patients aware of hypertension but not currently on treatment.

5. Increased case detection: e.g. 5% of population aged 40 years and over offered screening in community pharmacy [30].

For simplicity, the policy options that were modelled assumed a one-off change, instituted in a single year for a proportion of the current prevalent population with hypertension. The model then estimates consequent health effects and costs over the remaining lifetime for those individuals. The impact of extending the policies to more patients in future years (whether members of the initial prevalent population or to new incident cases) could be estimated in separate modelled scenarios.

Note that the modelled examples do not generally assume 100% uptake of the suggested treatment changes, because it is not likely that such major shifts in practice could be achieved in a single year. In addition, there are individual factors not included in the model that mean that the changes would not be clinically appropriate for all patients. For example, treatment may reasonably differ for patients with co-morbidities: such as use of beta blockers for patients with cardiac arrhythmia or ACEi/ARB for those with heart failure. And some patients may be contra-indicated or intolerant of some antihypertensive medications. It should also be noted that the estimated numbers of people in the modelled subgroups include people with secondary hypertension (attributable to a specific secondary cause) and also some people with pre-existing diabetes and/or cardiovascular disease. The model estimates of baseline risk and treatment effectiveness will not be accurate for these groups.

The model could be used to evaluate variations on the above policies, for example by assuming different proportions of patients starting or switching medication. Further adaptation would also be possible to assess other types of policy. Key priorities would include:

6. Combination antihypertensive treatment at first line, or for patients who do not achieve adequate control of blood pressure on monotherapy [10].

7. Primary prevention of hypertension through lifestyle interventions: for example, community based education to reduce dietary salt [31, 32].

Appendix D: Technical Description of Ghana Hypertension Model

Outcomes: The model estimates the incidence of five types of adverse event related to hypertension and modified by the use of antihypertensive medication:

- Coronary Heart Disease (CHD)
- Stroke
- Heart failure
- Type 2 diabetes and
- All-cause mortality.

In addition, Disability Adjusted Life Years (DALYs) and healthcare costs associated with interventions and incident adverse events are estimated.

Framework for evaluation: Reference Case

The model time step (cycle length), duration of treatment, time horizon and maximum age can be easily changed. The results below are presented using a one-year time step, a 60-year treatment duration time horizon, and a maximum age of 90. Budget impact is calculated for each year over a 5-year period.

Costs were estimated from an NHIS perspective, including the costs of antihypertensive medications and (where possible) the cost of policy implementation, in addition to the cost of diagnosis, treatment and care for adverse events. The proportion of the population covered by the NHIS was assumed to be 42%, and 80% of covered patients were assumed to access a defined package of NHIS-funded services following an adverse event. These assumptions about coverage and access can be changed. Due to time and data constraints, costs to other healthcare insurers, out of pocket expenditure by patients and their families, and the value of lost production due to ill-health or use of healthcare were not included in this version of the model. It was agreed that these other societal costs should be added at a later time.

DALYs were used as the primary measure of the value of health improvements: including time lived with disability and years of life lost due to the included adverse events. Age-weights were included in the DALY calculations, but these can be easily turned off for sensitivity analysis. Costs and DALYs were both discounted at 3% per year.

Results are presented using an incremental analysis: comparing each non-dominated option with the next most effective, non-dominated alternative using an Incremental Cost-Effectiveness Ratio (ICER) (the additional cost per DALY avoided). A maximum threshold for the ICER has not yet been defined, as the opportunity cost of displaced expenditure from NHIS covered services is not known. It therefore remains uncertain what additional cost per DALY avoided represents 'good value' for the NHIS. Further analysis and debate is required to agree on an appropriate and achievable cost-effectiveness benchmark for the NHIS.

The model includes the facility to conduct probabilistic sensitivity analysis (PSA), as well as deterministic sensitivity analysis to test the impact of uncertainties over parameter values and assumptions.

An evaluation of the current version of the model against the International Decision Support Initiative (iDSI) Reference Case criteria [33] is shown in Appendix E.

Appendix D: Technical Description of Ghana Hypertension Model

Modelling approach, structure and assumptions

The model structure is illustrated in Figure 6 below. It is a 'Markov type' or 'health state transition' model, which tracks the progress of a cohort of patients as they age over the defined time horizon.

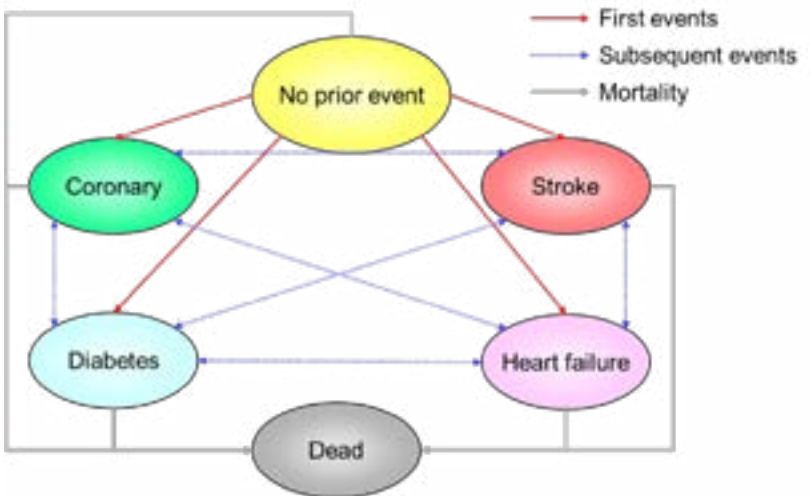

Figure 6. Illustration of model structure

The model includes six health states. Patients enter the model in the 'no prior event' health state. Over time they may experience one or more of the adverse events: non-fatal CHD, non-fatal stroke, onset of diabetes, onset of heart failure or death (from CVD or other causes). At any point in time, patients must be in one and only one of these health states, but they can move between health states in successive time periods as new events occur. If patients survive a first event, they are then at increased risk of a second event.

The model is set up with a cycle length (the minimum time step) of one year, which means that patients cannot experience more than one event within a year. Another simplifying assumption (the 'Markov assumption') is that patients' risks only depend on their current health state, not on their previous history. This assumption could also be relaxed, but not easily, as the model would have to be re-programmed to reflect a more complex structure: for example, to include additional health states for people who experienced two, three or more of the adverse events. However, the model is not a true Markov, because the risks of non-fatal events and mortality do increase as patients age.

As the model runs, information about the number of events and related healthcare costs and DALYs is accumulated. Two costs are associated with each non-fatal event: one for treatment in the first cycle after the event; and one for subsequent care for each cycle that the patient remains in the health state. Thus costs are high in the first year after a stroke, as they include costs for acute admissions and rehabilitation. If the patient survives for the first year, on-going costs for outpatient follow-up and preventive treatment are lower.

For the DALY calculations, years lived with disability are calculated by attaching a disability weight to each year spent in the non-fatal event states (CHD, stroke, diabetes, and heart failure) [27, 35]. In addition, years of life lost for each death are estimated using the usual WHO assumptions: according

Appendix D: Technical Description of Ghana Hypertension Model

to the upper limit of achievable life expectancy (from Japanese life tables). Other DALY assumptions included use of age weights and a 3% annual discount rate for DALYs. Costs were also discounted at a rate of 3% per year.

The model can be run automatically for each of the 48 subgroups defined by age, sex and level of hypertension, and for each treatment option (NI, ACEi, ARB, BB, CCB and TZD). Results for the whole population under alternative policy options are then obtained by averaging costs and health effects across the subgroups, according to the estimated number of people in each subgroup.

Parameters and sources of data

Population demography

The number of people in the Ghanaian population by sex and included age groups (age 20 years and older) was estimated from the 2010 census – see Table 5 [16]. People under the age of 20 were not included in the model, as we assumed that the prevalence of essential hypertension in children and teenagers would be negligible. Ghana has a young population, with over a third of the modelled population under the age of 30 years.

Age group	MEN	WOMEN	Total
20-29	2,043,940	2,329,662	4,373,602
30-39	1,467,069	1,633,143	3,100,212
40-49	1,025,595	1,098,853	2,124,448
50-59	653,182	703,611	1,356,793
60-69	363,294	406,426	769,720
70+	361,709	511,952	873,661
Total	5,914,789	6,683,647	12,598,436

Table 5. Number of people by sex and age group (20+) (2010 Census)[16]

The population in Ghana has grown since 2010, but for simplicity in this version of the model, the numbers have not been inflated to reflect this (this could be easily added). We also present result for the whole nation, but it would be possible to estimate costs and effects by region or socio-economic strata (e.g. by urban/rural location or wealth quintile).

Prevalence of hypertension

The 2014 Ghana DHS included measurement of blood pressure for a representative sample of the population: including 9,396 women between the ages of 15 and 49 and 4,388 men aged 15 to 59 [16]. These individuals were also asked if they were aware of having high blood pressure and if they were receiving treatment for high blood pressure.

Appendix D: Technical Description of Ghana Hypertension Model

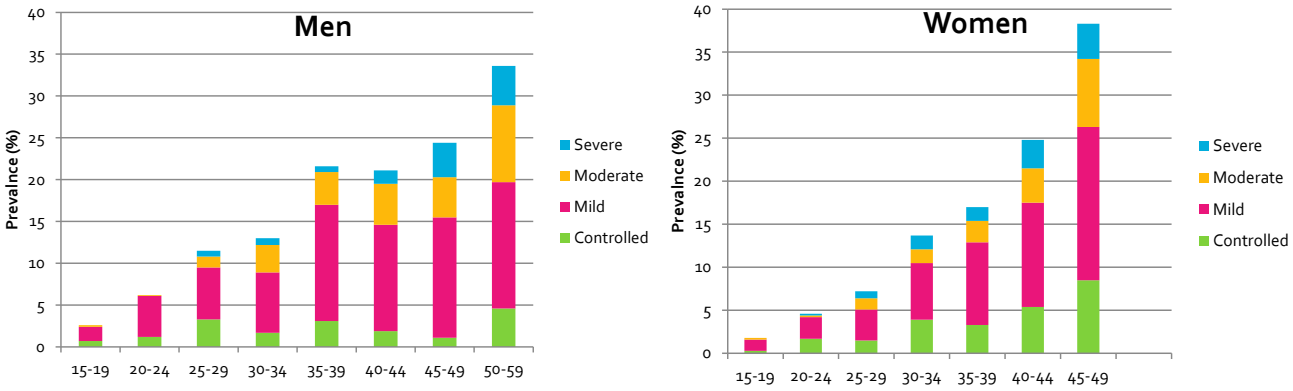

Figure 7. Prevalence of hypertension (GDHS 2014)[16]

The proportions of men and women in each age group with controlled, mild, moderate, and severe hypertension are shown in Figure 7. A greater proportion of women with hypertension were aware of this condition than were men with hypertension. As might be expected, a greater proportion of older people had hypertension than did young people (with a steeper percentage increase per year in women).

The numbers of people in the 120-modelled subgroups were estimated from the data in Table 6. The prevalence of hypertension in men over the age of 60 and women over the age of 50 were estimated by simple linear extrapolation from the observed prevalence in younger age groups: 0.79% (standard error (SE): 0.05%) increase per year for men and 1.14% per year for women (SE 0.15%). The numbers of people in each subgroup were sampled probabilistically for the PSA: using beta distributions to sample the prevalence of hypertension and Dirichlet distributions to sample the split of those with controlled, mild, moderate and severe hypertension for each age/sex group.

	Treated	Not aware (NA)			Aware not treated (ANT)			Treated not controlled (TNC)		
	Controlled	Mild	Mod.	Severe	Mild	Mod.	Severe	Mild	Mod.	Severe
MEN										
20-29	45,989	103,785	13,090	6,545	3,620	457	228	6,034	761	381
30-39	34,564	138,737	48,176	10,148	4,840	1,681	354	8,066	2,801	590
40-49	15,902	126,221	45,591	25,300	4,403	1,590	883	7,338	2,651	1,471
50-59	30,136	90,505	55,142	28,170	3,157	1,924	983	5,262	3,206	1,638
60-69	20,052	60,220	36,690	18,744	2,101	1,280	654	3,501	2,133	1,090
70+	24,872	74,698	45,511	23,250	2,606	1,588	811	4,343	2,646	1,352
WOMEN										
20-29	37,275	53,933	13,262	8,841	3,424	842	561	13,697	3,368	2,245
30-39	59,120	100,194	25,333	19,897	6,361	1,608	1,263	25,446	6,434	5,053
40-49	74,825	122,537	48,152	30,558	7,780	3,057	1,940	31,121	12,229	7,761
50-59	63,555	104,081	40,899	25,955	6,608	2,597	1,648	26,433	10,387	6,592
60-69	46,922	76,842	30,195	19,163	4,879	1,917	1,217	19,515	7,669	4,867
70+	75,182	123,122	48,382	30,704	7,817	3,072	1,949	31,269	12,287	7,798

Table 6. Estimated number of people with hypertension by subgroup

Appendix D: Technical Description of Ghana Hypertension Model

Baseline risks of adverse events

Annual mortality rates for individuals without CVD, diabetes or heart failure were taken from the World Health Organization life table for Ghana, published in 2016 (see Table 7) [18].

	Probability per year	
Age Group	Male	Female
25-34	0.00449	0.00350
35-44	0.00599	0.00549
45-54	0.00996	0.00798
55-64	0.02032	0.01588
65-74	0.04975	0.04402
75-84	0.13624	0.12676
85-94	0.31228	0.29181
95-100	0.54465	0.51155

Table 7. All-cause mortality with no prior event (WHO Ghana life table 2016)[18]

The annual probabilities of first incidence of CHD, stroke, heart failure and diabetes for each subgroup in the absence of treatment were estimated from international data. It would have been preferable to use estimates of incidence from Ghana, or other West African countries with a similar population and healthcare profile, but we have not been able to identify good quality cohort studies with longitudinal follow up of a population sample from these contexts.

Baseline estimates of the incidence of CVD (CHD and stroke) were taken from a multivariate analysis of primary care data for black African patients living in the UK (the QRisk2 algorithm) [21]. The derivation cohort included 6,917 individuals of Black African ethnicity, with 33 incidence CVD cases observed in 12,869 person years of follow up. The resulting estimates of incidence over ten years for men and women by age group in the absence of other risk factors are shown in Table 8. For the PSA, incidences by age/sex subgroup were sampled from beta distributions. Additional uncertainty was assumed around these probabilistic estimates due to the extrapolation of UK data (by assuming an effective sample size of 200 per subgroup).

Age	MEN	WOMEN
25	0.4%	0.9%
35	1.9%	1.7%
45	4.9%	3.2%
55	9.2%	6.0%
65	15.4%	11.1%
75	24.9%	20.1%
N	**3,316**	**3,655**

Table 8. Ten-year Incidence of CVD in black African patients with no other risk factors (QRisk2)[21]

Appendix D: Technical Description of Ghana Hypertension Model

The relative incidences of CHD, stroke and heart failure were estimated from a meta-analysis of trials of antihypertensive medications [13]. This reported 3,928, 2,220 and 1,844 incident cases of CHD, stroke and heart failure over a total 205,828 person years of follow up: proportions of coronary events and heart failure per case of CVD were 36.8% and 38.3% respectively. These proportions were sampled for the PSA using beta distributions.

The QRisk2 estimates of incidence cited in Table 9 are for people with normal blood pressure (SBP of 135) and no other risk factors. We adjusted the estimated risks of CHD, stroke and heart failure for people with mild, moderate and severe hypertension using relative risks per 10mm Hg increase in SBP from a pooled analysis of large cohort studies (see Table 9) [19]. These relative risks were sampled probabilistically from a log-normal distribution, with standard error based on the reported 95% confidence intervals.

		Mean	95% CI	
CHD	35-44	1.68	1.29	2.20
	45-54	1.56	1.29	1.89
	55-64	1.45	1.29	1.62
	65-74	1.33	1.29	1.38
	75-84	1.26	1.24	1.28
	85+	1.14	1.00	1.30
Stroke	35-44	2.05	1.89	2.22
	45-54	1.83	1.72	1.93
	55-64	1.63	1.57	1.69
	65-74	1.44	1.39	1.50
	75-84	1.28	1.21	1.35
	85+	1.10	1.03	1.18
HF	35-44	2.86	2.67	3.06
	45-54	2.49	2.37	2.61
	55-64	2.16	2.09	2.24
	65-74	1.88	1.82	1.94
	75-84	1.63	1.56	1.71
	85+	1.37	1.28	1.48

Table 9. Relative risk per 10mm Hg higher SBP (Singh et al 2013) [19]

Appendix D: Technical Description of Ghana Hypertension Model

Incidence of type 2 diabetes in people with hypertension was estimated from the QDiabetes algorithm, based on a multivariate analysis of 17,057 black African patients living in the UK: see Table 10 [20]. These estimates were used for the hypertensive population in our model, irrespective of the level of blood pressure (controlled, mild, moderate or severe). The risks of diabetes in each age/sex subgroup were sampled probabilistically, assuming an effective sample size of 500 per subgroup (less than the actual number of observed person years to increase uncertainty due to extrapolation from the UK context).

Age	MEN	WOMEN
25	0.9%	0.9%
35	4.6%	3.5%
45	12.2%	8.8%
55	21.1%	15.5%
65	25.1%	19.4%
75	22.3%	18.3%
N	**7,695**	**9,362**

Table 10. Incidence of type 2 diabetes in black African patients with hypertension (QDiabetes) [20]

The baseline risks of CHD, stroke, heart failure, diabetes, and all-cause mortality were assumed to double following an initial non-fatal event.

Treatment effects

The effects of antihypertensive treatment were estimated from high quality meta-analyses of international trial data. There is good evidence that the effects of the main classes of antihypertensive drugs vary by ethnicity [36]. Brewster et al reported estimates of the mean reduction in systolic blood pressure in black patients, pooled from 26 RCTs: see Table 11. This shows that in this population, CCBs and TZD medications are more effective at reducing blood pressure.

	Reduction (mmHg)		
	Mean	95% CI	
ACEi	6.96	4.27	9.64
ARB	3.63	1.78	5.47
BB	3.53	-0.45	7.51
CCB	12.46	10.08	14.85
TZD	11.81	9.55	14.07

Table 11. Mean reduction in SBP for black patients (Brewster et al 2004)[15]

Ettehad *et al* (2016) reported summary estimates of the effects of blood pressure lowering on the incidence of different endpoints: CHD, stroke, heart failure and all-cause mortality: see Table 12 [13]. Effects on the incidence of new onset of diabetes was reported by Elliot and Meyer (2007) [14].

Appendix D: Technical Description of Ghana Hypertension Model

	Relative risk per 10mm HG reduction			Source
	Mean	95% CI		
CHD	0.83	0.78	0.88	Ettehad et al 2016[13]
Stroke	0.73	0.68	0.77	Ettehad et al 2016[13]
HF	0.72	0.67	0.78	Ettehad et al 2016[13]
Death	0.87	0.84	0.91	Ettehad et al 2016[13]
Diabetes	0.87	0.75	1.01	Elliot et al 2007[14]

Table 12. Relative risk of adverse events with blood pressure lowering

There is also evidence that different classes of antihypertensive vary in their relative effects on these endpoints: see Table 13.

		RR vs pooled comparators*			RR of outcome in black population (vs. control)
		Mean	95% CI		
ACEi	CHD	0.95	0.90	1.01	0.85
	Stroke	1.08	1.01	1.16	0.85
	HF	0.98	0.92	1.05	0.80
	Diabetes	0.87	0.75	1.01	0.83
	Death	1.01	0.97	1.05	0.92
ARB	CHD	1.06	0.98	1.15	0.96
	Stroke	0.92	0.85	0.99	0.88
	HF	0.96	0.89	1.04	0.89
	Diabetes	0.75	0.61	0.91	0.87
	Death	0.99	0.94	1.04	0.95
BB	CHD	1.03	0.96	1.10	0.95
	Stroke	1.24	1.14	1.35	0.97
	HF	1.04	0.93	1.16	0.91
	Diabetes	1.17	0.98	1.40	1.01
	Death	1.06	1.01	1.12	0.97
CCB	CHD	0.98	0.94	1.03	0.77
	Stroke	0.90	0.85	0.95	0.57
	HF	1.17	1.11	1.24	0.80
	Diabetes	0.97	0.82	1.15	0.81
	Death	0.97	0.94	1.00	0.81
TZD	CHD	1.02	0.97	1.09	0.82
	Stroke	0.97	0.90	1.05	0.66
	HF	0.81	0.75	0.88	0.51
	Diabetes	1.30	1.07	1.58	1.15
	Death	1.02	0.97	1.06	0.87

Table 13. Relative risk of adverse events by antihypertensive class

Appendix D: Technical Description of Ghana Hypertension Model

The model combines the above estimates of the effect of antihypertensive class on blood pressure lowering in black patients, the overall effect of blood pressure lowering on the incidence of adverse outcomes, and the relative effect of different antihypertensive class on these outcomes. These estimates are shown in the right hand column of Table 13. Probabilistic estimates of these relative risks are sampled, based on the reported confidence intervals from the underlying meta-analysis estimates: assuming a normal distribution for the reduction in mean SBP (Table 11) and log-normal for the relative risks with blood pressure lowering (Table 12) and per antihypertensive class (Table 13).

Medication costs

The costs of antihypertensive medications are based on the NHIS price for drugs on the essential medicines list, and assuming a daily dose as recommended in the Ghana Standard Treatment Guidelines (median of range) [22, 25, 37]. Some data were available on the level of prescribing by drug, but not by brand or formulation. Based on the NHIS price, and estimated use within class, the mean cost per year ranged from GH¢ 26 per year for diuretics to GH¢ 399 per year for CCBs (see Table 14). In sensitivity analysis, we also tested the impact of using the least and most expensive drug and formulation within each class.

Appendix D: Technical Description of Ghana Hypertension Model

	Daily dose	Cost per year			% use in class NHIS
		NHIS	Lowest generic	Highest branded	
ACEi					
Lisinopril 2.5mg Tablet	22.5	690	690	690	25%
Lisinopril 5mg Tablet	22.5	345	181	2957	25%
Lisinopril 10mg Tablet	22.5	246	205	2751	25%
Lisinopril 20mg Tablet	22.5	177	90	1992	25%
Ramipril 2.5mg Tablet	6.3	274	256	420	0%
Ramipril 5 mg Tablet	6.3	228	160	228	0%
					364
ARB					
Losartan 25mg Tablet	62.5	365	237	365	33%
Losartan 50mg Tablet	62.5	228	125	282	33%
Losartan 100mg Tablet	62.5	183	91	237	33%
					259
BETA BLOCKERS					
Atenolol 25 mg Tablet	75	142	126	142	33%
Atenolol 50 mg Tablet	75	110	77	110	33%
Atenolol 100 mg Tablet	75	55	49	55	33%
					102
CCB					
Amlodipine 5mg Tablet	7.5	110	93	2738	8%
Amlodipine 10mg Tablet	7.5	82	52	2190	8%
Nifedipine 10mg Capsules	50	894	894	1898	21%
Nifedipine 10mg (slow release)	50	456	456	548	21%
Nifedipine 30mg (GITS)	50	335	335	1570	21%
Nifedipine 20mg (slow release)	50	155	155	456	21%
					399
DIURETICS					
Bendrofluazide 2.5 mg Tablet	2.5	26	26	51	100%
Bendrofluazide 5 mg Tablet	2.5	18	18	26	
					26

* Ettehad et al (2016)[13] for CHD, stroke, heart failure and all-cause mortality. Elliot and Meyer (2007)[14] for incident type 2 diabetes.

Table 14. Antihypertensive prices

Appendix D: Technical Description of Ghana Hypertension Model

Adverse event costs

The unit costs of services were based on a weighted average of NHIS tariffs for public hospitals, private hospitals and tertiary hospitals (Table 15) [23, 24, 26]. For the base case analysis we assumed a distribution of 40%, 40% and 20% for public, private and tertiary hospitals respectively, with uncertainty over this distribution included in the PSA (Dirichlet distribution, with assumed sample size of 100 to reflect high uncertainty over this assumption).

	G-DRG	Public	Private	Tertiary	Value us
MDC: MEDICAL					
DRG - Ischaemic Heart Disease	MEDI33A	175.82	245.53	225.56	213
DRG - CVA/ stroke	MEDI14A	205.71	298.84	315.88	265
DRG - Heart disease	MEDI07A	220.16	333.35	324.47	286
DRG - Diabetes (simple >12 years)	MEDI02A	154.40	240.64	197.25	197
MDC: OUTPATIENT					
General OPD - Adult	OPDC06A	11.42	19.11	19.97	16
MDC: INVESTIGATIONS					
ECG	INVE41D	4.49	6.21	5.33	5
Full blood count (FBC automation)	INVE52D	6.24	6.76	7.08	6
Liver function test (LFT)	INVE74D	11.42	11.83	12.28	11
Lipid profile	INVE75D	10.34	10.86	11.20	10
Renal function tests (U&Es)	INVE21D	7.62	8.13	8.47	7
2 hour post prandial blood glucose	INVE01D	5.51	6.56	6.35	6
Fasting blood sugar/ random blood sugar	INVE46D	3.29	3.56	4.14	3
COMMUNITY					
Physician visit (GP)					10
Pharmacist (per day)					100
Pharmacy assistant (per day)					50

Table 15. Unit costs of services: Ghana NHIS Tariffs [23, 24, 26]

Estimates of the cost to the NHIS of diagnosis, treatment and care associated with adverse events are shown in Table 16 (year 1) and Table 17 (subsequent years).

The percentage of patients assumed to access a package of covered services was 80% in the base case, varying between 60% and 100% (uniform distribution) in PSA. The package of services for stroke was based on recommended outpatient follow up every 2 weeks for 4 times after discharge, then every month for 3 times, then every six months for at least 3 years. We assumed similar follow up after acute admission for CHD and heart failure.

Appendix D: Technical Description of Ghana Hypertension Model

	% patients	Quantity	Unit cost	Cost
Coronary Heart Disease				
DRG - Acute admission	0.80	1	213.65	170.92
Follow-up specialist consultation	0.80	7	16.21	90.75
ECG	0.80	7	5.35	29.94
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	7	35.19	197.06
Drugs (Asp, BB, ACEi, Statin)	0.80	1	30.00	24.00
				512.68
Stroke				
DRG - Acute admission	0.80	1	265.00	212.00
Follow-up specialist consultation	0.80	7	16.21	90.75
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	7	35.19	197.06
Drugs (Asp or warfarin, anti-BP, Statin)	0.80	1	34.00	27.20
				527.01
Heart failure				
DRG acute admission	0.80	1	286.30	229.04
Consultations (specialist)	0.80	7	16.21	90.75
ECG	0.80	7	5.35	29.94
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	7	35.19	197.06
Drugs (ACEi, BB, Diuretic, Dig, Spiro)	0.80	1	22.00	17.60
				564.39
Diabetes				
DRG - Diabetes	0.80	1	197.47	157.97
Consultations (specialist)	0.80	1	16.21	12.96
ECG	0.80	1	5.35	4.28
Blood tests (PPBG, Lipids, LFT, RFT)	0.80	1	36.57	29.25
Physician visit (GP)	0.80	2	10.20	16.32
Fasting blood glucose	0.80	6	3.57	17.13
Annual eye and feet tests	0.80	1	16.21	12.96
Drugs (Hypog, Asp, ACEi, Statin)	0.80	1	29.00	23.20
				274.08

Table 16. Cost of adverse events: first year

	% patients	Quantity	Unit cost	Cost
Coronary Heart Disease				
Specialist visit	0.80	2	16.21	25.93
ECG	0.80	2	5.35	8.55
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	2	35.19	56.30
Drugs (Asp, BB, ACEi, Statin)	0.80	1	30.00	24.00
				114.79
Stroke				
Stroke				
Specialist visit	0.80	2	16.21	25.93
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	2	35.19	56.30
Drugs (Asp or warfarin, anti-BP, Statin)	0.80	1	34.00	27.20
				109.43
Heart failure				
Heart failure				
Specialist visit	0.80	2	16.21	25.93
ECG	0.80	2	5.35	8.55
Blood tests (FBC, Lipids, PPBG, LFTs)	0.80	2	35.19	56.30
Drugs (ACEi, BB, Diuretic, Dig, Spiro)	0.80	1	22.00	17.60
				108.39
Diabetes				
Diabetes				
Physician visit (GP)	0.80	2	10.20	16.32
Blood tests (PPBG, Lipids, LFT, RFT)	0.80	2	36.57	58.51
Fasting blood glucose	0.80	2	3.57	5.71
Annual Eye and feet tests	0.80	1	19.11	15.29
Drugs (Hypog, Asp, ACEi, Statin)	0.80	1	29.00	23.20
				119.03

Table 17. Cost of adverse events: subsequent year

Appendix D: Technical Description of Ghana Hypertension Model

DALY calculations

Years of life lost by age, and the disability loss per year lived with CHD, stroke, heart failure and type 2 diabetes are shown in Table 18.

Years of life lost by age are based on standard life expectancy, discounted at 3% per year. Disability weights for CHD, stroke, heart failure and type 2 diabetes were 0.124, 0.266, 0.201 and 0.015 respectively, from the 2003 WHO estimates [38]. We could not use more recent estimates of disability weights, because these have not been presented as averages for these broad conditions, but by a more detailed breakdown of level of disability and type of complication [28]. In the base case, the model uses the default constant of 0.1658 and age-weight parameter of 0.04. These parameters can be changed for sensitivity analysis.

Age at onset	Standard life expectancy	Years of life lost	Disability loss per year (age weighted)			
		Death	CHD	Stroke	HF	T2D
MEN						
0	79.9	33.1	0.012	0.025	0.019	0.001
1	77.8	35.2	0.055	0.119	0.090	0.007
5	73.1	37.2	0.115	0.248	0.187	0.014
10	67.5	37.2	0.159	0.341	0.258	0.019
15	62.4	35.8	0.179	0.384	0.290	0.022
20	57.9	33.8	0.186	0.398	0.301	0.022
25	53.0	31.1	0.185	0.397	0.300	0.022
30	48.0	28.0	0.178	0.383	0.289	0.022
35	43.1	24.9	0.168	0.361	0.273	0.020
40	38.1	21.7	0.156	0.334	0.252	0.019
45	33.2	18.5	0.142	0.305	0.230	0.017
50	28.5	15.6	0.128	0.276	0.208	0.016
55	23.9	12.7	0.115	0.247	0.187	0.014
60	19.5	10.1	0.102	0.219	0.166	0.012
65	15.4	7.7	0.090	0.194	0.146	0.011
70	11.8	5.7	0.080	0.171	0.129	0.010
75	8.8	4.0	0.070	0.150	0.113	0.008
80	6.4	2.7	0.061	0.131	0.099	0.007
85	3.9	1.5	0.051	0.108	0.082	0.006
WOMEN						
0	82.4	33.2	0.012	0.025	0.019	0.001
1	80.3	35.3	0.055	0.119	0.090	0.007
5	75.6	37.3	0.116	0.250	0.189	0.014
10	70.4	37.5	0.157	0.337	0.254	0.019
15	65.2	36.1	0.178	0.383	0.289	0.022
20	60.5	34.0	0.186	0.398	0.301	0.022
25	55.7	31.4	0.185	0.397	0.300	0.022
30	50.7	28.3	0.178	0.382	0.289	0.022
35	45.9	25.3	0.168	0.361	0.273	0.020
40	41.0	22.1	0.156	0.334	0.252	0.019
45	36.2	19.0	0.142	0.305	0.230	0.017
50	31.6	16.2	0.129	0.276	0.209	0.016

Table 18. Years of life lost and disability loss per year by adverse event and age of onset

Appendix D: Technical Description of Ghana Hypertension Model

Results

Base case deterministic results: treated population

Results can be calculated for different sections of the population. Here we present results for approximately 340,000 people estimated to be covered by the NHIS (42% of the population) and receiving treatment for hypertension, including those with adequately controlled blood pressure, and those with mild, moderate and severely raised blood pressure despite treatment (see Table 19).

Age group	Controlled	Mild	Moderate	Severe	Total
MEN					
25	19,315	2,534	320	160	22,329
35	14,517	3,388	1,176	248	19,329
45	6,679	3,082	1,113	618	11,492
55	12,657	2,210	1,347	688	16,902
65	8,422	1,470	896	458	11,246
75	10,446	1,824	1,111	568	13,949
WOMEN					
25	15,656	5,753	1,415	943	23,766
35	24,830	10,687	2,702	2,122	40,342
45	31,427	13,071	5,136	3,260	52,893
55	26,693	11,102	4,363	2,769	44,926
65	19,707	8,196	3,221	2,044	33,169
75	31,576	13,133	5,161	3,275	53,145
Total	221,925	76,451	27,960	17,151	343,488

Table 19. Estimated number of people receiving NHIS treatment for hypertension

The estimated numbers of adverse events over the full time horizon per 1,000 patients treated are shown in Figure 8. Compared with no intervention, all classes of antihypertensive are expected to reduce the number of coronary events, strokes and incident cases of heart failure. CCBs, ACEi and ARBs are also expected to reduce incidence of type 2 diabetes, but TZD and BB are estimated to increase diabetes incidence. CCBs are most effective at preventing coronary events and strokes, although TZD are better at preventing heart failure.

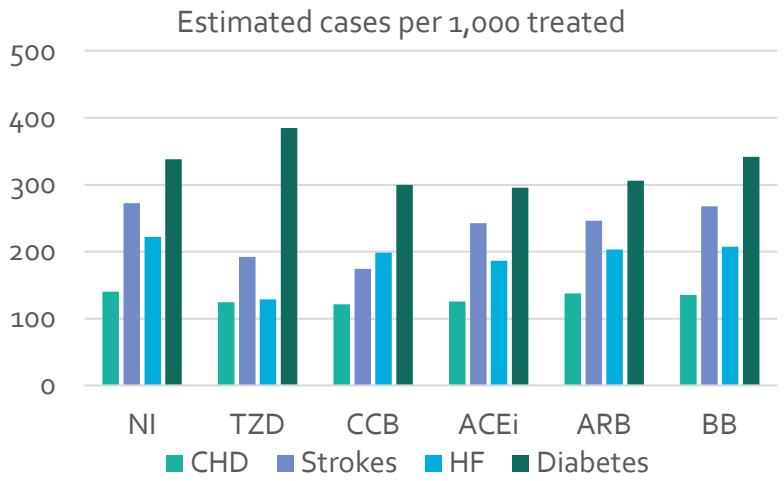

Figure 8. Estimated number of adverse events in treated population (lifetime incidence)

Appendix D: Technical Description of Ghana Hypertension Model

The number of DALYs avoided and additional costs compared with no intervention are illustrated in Figure 9. This shows that BB, ARB and ACEi are dominated diuretics in this population: with fewer DALYs avoided and higher costs. This result was robust to sensitivity analysis. Compared with TZD, CCBs are estimated to be more effective (with more DALYs avoided) but more expensive.

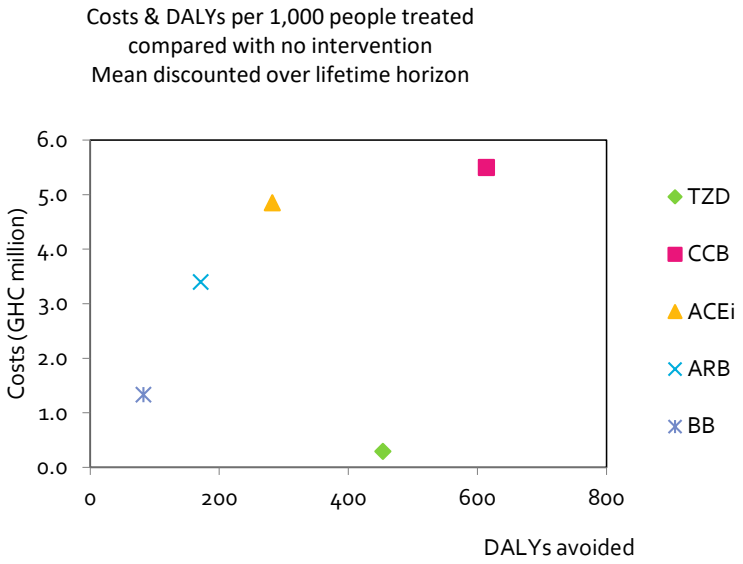

Figure 9. Costs and effects compared with no intervention: currently treated population

The additional costs and DALYs avoided for each drug class compared with no intervention are shown in Table 20. 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 costs an additional GH¢ 5.2 million and avoids a further 160 DALYs: an ICER of over GH¢ 30,000 per DALY avoided.

	Compared with no intervention		ICER (GH₵ per DALY avoided)
	Additional cost (GH₵)	DALYs avoided	
TZD	290,933	453	642
CCB	5,498,126	614	32,482
ACEi	4,847,175	282	Dominated
ARB	3,398,147	171	Dominated
BB	1,334,573	83	Dominated

Table 20. Incremental cost-effectiveness analysis: per 1,000 treated population

The estimated impact on the NHIS budget is shown in Table 21. For the whole NHIS-covered population estimated to be treated for hypertension, the estimated cost of TZD would be GH¢ 26.3 million over five years. The cost of prescribing a CCB is much higher (over GH¢ 480 million over five years).

Appendix D: Technical Description of Ghana Hypertension Model

	Total costs (GH₵ discounted)				
	Year 1	Year 2	Year 3	Year 4	Year 5
NI	5,347,183	6,082,649	6,499,465	6,708,038	6,781,829
TZD	8,181,309	12,548,675	12,526,516	12,373,027	12,134,744
CCB	69,386,769	127,865,019	121,118,914	114,705,942	108,654,743
ACEi	64,168,270	117,113,688	110,582,387	104,394,251	98,589,550
ARB	47,124,757	84,772,356	80,167,115	75,758,854	71,599,337
BB	21,841,437	37,149,504	35,569,569	33,942,948	32,335,183
TZD vs NI	2,834,127	6,466,027	6,027,051	5,664,989	5,352,915
CCB vs TZD	61,205,459	115,316,343	108,592,399	102,332,914	96,519,999

Table 21. NHIS Budget impact for whole treated population (343,488 patients)

Despite considerable parameter uncertainty, the probabilistic analysis suggests that the overall conclusions about the relative cost-effectiveness of the drug classes are robust. Based on 1,000 PSA iterations:

- The ICER for diuretics compared with no intervention was estimated at GH¢ 677 per DALY avoided (95% of iterations between 561 to 803);
- The ICER for CCBs compared with diuretics was GH¢ 32,248 (95% from 25,708 to 41,255).

Figure 10 shows how the estimated probability of the most cost-effective drug class varies with the willingness-to-pay to avoid a DALY. Below a threshold of GH¢ 500 per DALY avoided, the probability that any of the antihypertensive classes are cost effective is negligible. Between about GH¢ 900 and GH¢ 24,200 per DALY avoided, it appears almost certain that diuretics are the most cost-effective option. Above GH¢ 24,200 per DALY avoided the probability that CCB are cost-effective begins to rise, until above GH¢ 46,900 per DALY avoided this appears almost certain (100% of PSA iterations).

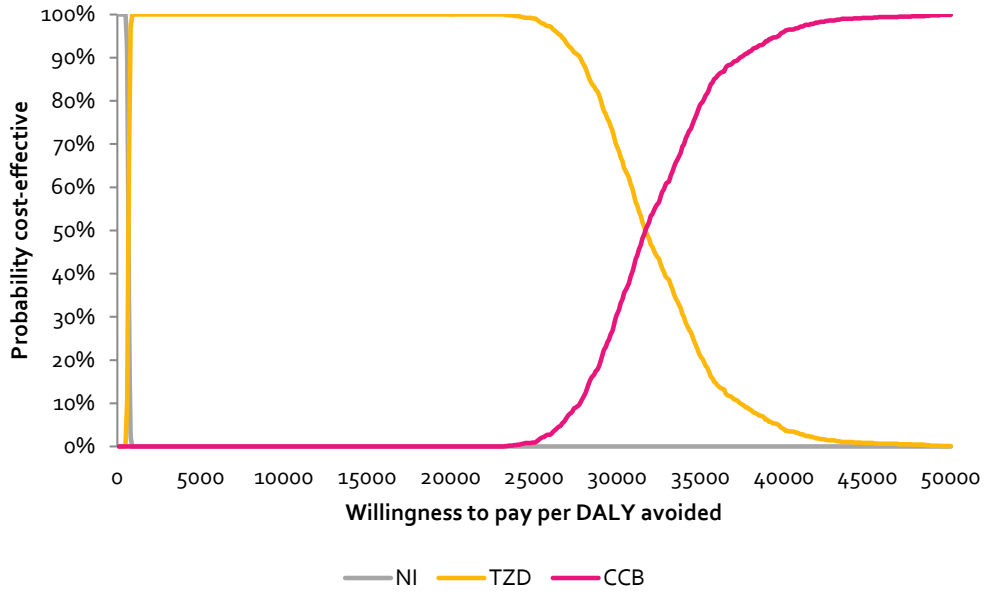

Figure 10. Cost effectiveness acceptability curves (CEAC)

Appendix E: iDSI Reference Case- Assessment of Ghana Hypertension Model

	Statement of principle	Reference Case Methods Specifications	Ghana Hypertension Model Specifications	Comments
1	**An economic evaluation should be communicated clearly and transparently to allow the decision maker(s) to interpret the methods and results**	• The decision problem must be fully and accurately described and the economic evaluation characterised.	✓	
		• Limitations of the economic evaluation in informing policy should be characterised.	✓	
		• Declarations of interest should be made.	✗	KC, JL, and MG declare that they do not have any conflicts of interest. No conflicts of interest were declared by the WG members, although declarations were not documented.
2	**The comparators against which costs and effects are measured should accurately reflect the decision problem.**	• At a minimum, the following comparative analysis should be undertaken: ○ The intervention(s) that is (are) currently offered to the population as defined in the decision problem as the base case comparator. ○ A "do nothing" analysis representing best supportive (non-interventional care) for the population as additional analysis.	✓	

Appendix E: iDSI Reference Case- Assessment of Ghana Hypertension Model

3	**An economic evaluation should consider all available evidence relevant to the decision problem**	• A systematic and transparent approach should be taken to obtain evidence and make judgements about evidence exclusion.	✓	
		• Estimates of clinical effect of intervention and comparator(s) should be informed by a systematic review of the literature.	✓	
		• Single-study or trial-based analyses should outline how the single study or trial is a sufficient source of evidence and should ensure that the stated decision problem is specific to particular context and time of the study or trial.	✓	
		• Budget and time allocated to perform an economic evaluation should not determine selection of evidence.	✓	
4	**The measure of health outcome should be appropriate to the decision problem, should capture positive and negative effects on length of life and quality of life, and should be generalizable across disease states**	• Disability-Adjusted Life Years (DALYs) averted should be used [stated methodological specification].	✓	
		• Other generic measures that capture length and quality of life (e.g. the QALY) can be used in separate analysis where information is available.	✓	

Appendix E: iDSI Reference Case- Assessment of Ghana Hypertension Model

5	**All differences between the intervention and the comparator in expected resource use and costs of delivery to the target population(s) should be incorporated into the evaluation**	• Estimates should reflect the resource use and unit costs/prices that are expected if the intervention were to be rolled out to the population defined in the decision problem.	✓	
		• Costs not included in study settings used to inform the analysis but would be incurred if the intervention was rolled out should be included in the base case analysis.	✓	
		• All resource implications relevant to the decision problem should be costed, including donated inputs and out of pocket inputs from individuals.	✗	This version of the model only includes costs to the NHIS. It was agreed that costs to other payers should be added, but this would require further data collection.
		• Analysis should include estimation of changes in costs estimates due to scalability.	✓	

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6	**The time horizon used in an economic evaluation should be of sufficient length to capture all costs and effects relevant to the decision problem; an appropriate discount rate should be used to discount cost and effects to present value**	• Lifetime time horizon should be used in first instance.	✓	
		• Shorter time horizon can be used where shown that all costs and effects that are relevant to the decision problem have been captured.	✓	
		• A 3% annual discount rate for costs and effects should be used in base case analysis [stated methodological specification]. Additional analysis exploring differing discount rates appropriate to the decision problem should be used.	✓	
		• Additional analysis should explore an annual discount rate that reflects the rate at which the government can borrow funds on the international market.	✗	It is straightforward to conduct sensitivity analysis on the discount rates, but advice is needed on government borrowing rates.
		• Where time horizon used is greater than 30 years, the impact of lower discount rates should be explored in sensitivity analysis.	**n/a**	

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7	**Non-health effects and costs associated with gaining or providing access to health interventions that don't accrue to the health budget should be identified where relevant to the decision problem. All costs and effects should be disaggregated, either by sector of the economy or to whom they accrue**	• Base case analysis should reflect direct health costs and health outcomes; however the analysis should adopt a disaggregated societal perspective.	✓	
		• Non-health effects and costs that fall outside the health budget should be included in additional analysis; the mechanism of inclusion will differ depending on the decision problem and context.	✗	
		• Where external funding or individual OOP payments substitute for costs that would otherwise fall on a health budget, these costs should be included in the base case analysis, however the impact of excluding these payments must be explored in sensitivity analysis.	✗	

Appendix E: iDSI Reference Case- Assessment of Ghana Hypertension Model

8	**The cost and effects of the intervention on sub-populations within the decision problem should be explored and the implications appropriately characterised**	• Heterogeneity should be explored in subgroups of the population identified in the decision problem, where subgroup formation should be informed by: ○ Relevant effect of the intervention differs in different populations. ○ Characteristics of different populations that may influence the absolute health effects. ○ Characteristics that influence direct costs of provision or other associated costs such as geographical location across the constituency.	✓	
		• Subgroup analysis should always be determined by: ○ The evidence base regarding differences in relative effect, baseline risk or other characteristics. ○ Whether the differences are likely to have an important influence on costs and effects.	✓	
9	**The uncertainty associated with an economic evaluation should be appropriately characterised**	• The economic evaluation should explore: ○ Uncertainty in the structure of the analysis. ○ Uncertainty due to source of parameters. ○ Uncertainty due to precision of parameters.	✓	
10	**The impact of implementing the intervention on the health budget and on other constraints should be identified clearly and separately**	• Budget impact analysis should be performed that provides an estimate of the implications of implementing the intervention on various budgets.	✓	
		• Budget impact analysis should reflect the decision problem and the constituency in which the intervention will be implemented.	✓	

Appendix E: iDSI Reference Case- Assessment of Ghana Hypertension Model

11	**An economic evaluation should explore the equity implications of implementing the intervention**	• There are various mechanisms available for how the equity implications of an intervention should be assessed. The method chosen should be appropriate to the decision problem and justifiable to the decision-maker.	✗	There was discussion of whether to disaggregate results for sections of the population (e.g. urban vs. rural). However, policy makers wanted to focus initially on national average results.
		• Equity implications should be considered at all stages of the economic evaluation, including design, analysis and reporting.	✗	As above.

*** This comparison against the iDSI RC is to demonstrate how the current study stands against various elements of the RC. A final Ghanaian RC will have to be discussed and agreed across Ghana's major stakeholders before being provided.*

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About iDSI

The International Decision Support Initiative (iDSI) is a global network of health, policy and economic expertise, working to achieve Universal Health Coverage and the health Sustainable Development Goal (SDG 3). We support countries to make better decisions about how much public money to spend on healthcare and how to make that money go further. We believe everyone should have fair access to health, receiving the right treatment and the right medicines at the right time.

A global network

iDSI forges regional and global partnerships that share the knowledge and support needed to achieve real world health gains. We focus on building institutional knowledge within existing health systems so countries can lead their own progress towards UHC.

Evidence-based decision making

Our work is underpinned by robust evidence, analysis and decision-making that policymakers, funders and researchers can use to balance trade-offs between different policy options and model potential results to make the best choice available. As a result, health ministries are equipped to make persuasive demands on public and donor spending that will save lives.

Long-term partnerships

Our work focuses on building the skills and expertise of those involved in national health systems so they can make the best use of finite resources to solve problems for current and future generations. As this expertise grows, we facilitate regional cooperation to increase contextual knowledge and skills sharing that will improve the impact and value of healthcare spending.

Our values

- Everyone should have fair access to health, receiving the right treatment and the right medicines at the right time.
- Health systems need to develop and maintain their own skills so they can make the best use of finite resources to solve problems for current and future generations.
- Sustainable and progressive health systems are only possible when they engage and involve those with a stake in its success, from the public through to funders.

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