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Equity impact analysis of medical approaches to cardiovascular diseases prevention in Tanzania

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ABSTRACT

Primary medical prevention of cardiovascular disease (CVD) has received low priority in Tanzania, despite evidence of the rising prevalence of CVD risk factors. Different guidelines have been proposed for medical CVD prevention, including the European Society of Cardiology (ESC) and the World Health Organization (WHO) guidelines, which recommend medical prevention for all individuals based on the consideration of single CVD risk thresholds. A third alternative is differentiated risk thresholds according to age. This paper compares the WHO and the differentiated risk threshold by age approaches against a baseline of no medical CVD prevention and a best scenario identical to the ESC approach in Tanzania. Assuming fixed budgets, we evaluate the guidelines according to three outcome measures, namely: efficiency, inequality and the combination of efficiency and inequality.

We ran a Markov analysis for an estimated Tanzanian population at risk of CVD employing a 40 years time horizon to estimate the total expected costs and CVD deaths associated with provision of the different guidelines. The results were then used to calculate three outcomes: life expectancy at age 40 as a proxy for efficiency, the Gini coefficient (a measure of inequality), and the achievement index (which combines concerns of efficiency and inequality).

Our results suggest that higher life expectancy (28.3 vs. 26.6 years) and more equally distributed health (Gini coefficient of 0.22 vs. 0.24) could be attained if medical CVD prevention was based on the differentiated risk threshold approach compared to the WHO single risk threshold, when the total cost of these approaches is the same.

Preventing CVD based on differentiating risk thresholds by age seems to be the better alternative when concerns of both efficiency and inequality are considered important. However, further research on the country-specific distribution of CVD risk levels and budget impact analysis are important to assess the feasibility of its implementation.

1. Introduction

The risk of cardiovascular disease (CVD) in many sub-Saharan African countries (SSA) is increasing (Dalal et al., 2011), and Tanzania is not different in this regard (Aspray et al., 2000; Bovet et al., 2002; Edwards et al., 2000; Hendriks et al., 2012; Njelekela et al., 2001, 2003, 2009). As such, the burden of disease caused by myocardial infarction (MI) and stroke, which are the two main forms of CVD, has increased by 60% in Tanzania during the period 1990 to 2013 (Institute of Health Metrics and Evaluation, 2013). CVD are projected to increase further in developing countries over the next 10–15 years (Kearney et al., 2005; Shaw et al., 2010).

Despite this increasing burden, primary prevention of CVD has lagged behind in the region. It receives low priority in research and policy documents, and is often practiced in a non-systematic and fragmentary way (World Health Organization, 2015). These practices of considering only one or two individual risk factors, for instance blood pressure levels and/or cholesterol levels (which we

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refer to as the individual risk factor approach)—without considering other related factors e.g. age, smoking status etc.—can be inefficient and in most cases lead to the over treatment and under treatment of some relatively low-risk and high-risk patients, respectively (Cobiac et al., 2012; Gaziano, 2007). Individual risk factor approach will therefore not be discussed further in this paper. An alternative approach recommended by the World Health Organization (WHO) and elsewhere (Cobiac et al., 2012; Ferket et al., 2010; Gaziano, 2007; Gaziano et al., 2005; World Health Organization, 2007) is based on the fact that the probability of a CVD event depends on many factors. This approach (which has been termed the absolute risk approach) combines major modifiable factors including hypertension, cholesterol level, and smoking and unmodifiable factors like age and sex to give the probability of a CVD event occurring in a given time period, e.g. ten years, which then forms the basis for the initiation of medical CVD primary prevention (National Vascular Disease Prevention Alliance, 2014). There are two different principles to the absolute risk approach which will be further scrutinized in this work. These are: (i) absolute risk based on single risk threshold, which is the commonest and has been the basis of the WHO and the European Society for Cardiology (ESC) guidelines, and (ii) absolute risk based on differentiated risk thresholds, as used in Norway.

1.1. Single risk threshold approaches

1.1.1. The WHO approach

The WHO has developed risk prediction charts for its regions, which use easily measurable indicators to obtain probabilities of CVD events (see Appendix 1). These tools are especially useful for low-income settings where capacity and resources are lacking to support the development of population-specific risk prediction charts. These charts group individuals into four CVD levels according to their 10-year absolute risk of a CVD event, namely: low risk (<9.9%), moderate risk (10–19.9%), high risk (20–29.9%), and very high risk (≥30%). The WHO then recommends medical prevention to those with moderate, high and very high absolute CVD risk levels, unless they are diabetic or other factors e.g. renal impairment exists, which makes medical management necessary regardless of CVD risk level (World Health Organization, 2007). The terms “10-year risk of a CVD event” and “risk threshold” are used interchangeably in this paper.

1.1.2. The ESC approach

The ESC guidelines use the same absolute risk approach in their guide to medical interventions to prevent CVD (see Appendix 2). Although the current version of the guidelines avoids being explicit about the threshold values that qualify individuals for medical intervention, it states that, in general, individuals with absolute risk of a CVD event of ≥5–9.9% may benefit from or frequently require medical prevention (Perk et al., 2012). It may not be pragmatic for Tanzania to adopt this policy of using low threshold values as the basis for medical CVD prevention due to its resource-constrained health system; however, it will be interesting to assess this approach as a best-case scenario comparator. We chose to define the WHO and ESC guidelines as single risk threshold guidelines since medical management decisions are based on one (single) threshold range irrespective of age.

1.2. Risk thresholds differentiated by age approach

Norway has chosen to divert from this single risk approach (having only one risk threshold irrespective of age) to a differentiated risk threshold approach (having different risk thresholds according to age). With the differentiated risk threshold approach, lower risk thresholds are assigned to younger age groups and higher risk thresholds to older ones (Norheim et al., 2011). Age is therefore used directly to predict the absolute risk of a CVD event and indirectly to determine the cut-off point for eligibility for medical CVD prevention. This follows concerns that the ESC guidelines would classify most elderly people as being eligible for medical prevention of CVD since the estimated CVD risk of an event (in these age categories) will often exceed the 5% level based on age and gender alone, even when other cardiovascular risk factors are relatively low (Getz et al., 2004; Graham et al., 2007; Hartz et al., 2005; Norheim et al., 2011). The current version of the ESC guidelines has attempted to deal with this challenge by introducing the concept of “cardiovascular risk age”, whereby the risk age of a person with several cardiovascular risk factors is equated with the age of a person with the same level of risk but with ideal levels of risk factors. For example, a hypertensive, smoking 40-year-old man can be considered to have a cardiovascular risk age similar to that of a normotensive, non-smoking 60-year-old man. However, this risk age is not currently used as a basis to determine eligibility for medical prevention of CVD (Perk et al., 2012).

There is vast evidence that CVD risk factors, e.g. use of tobacco, are high and becoming more prevalent in disadvantaged people of low socioeconomic status, as well as for low-income countries (LICs). Consequently, CVD affect these disadvantaged groups disproportionately (Mendis et al., 2011). Even though country-level evidence on the impact of inequalities associated with CVD in Tanzania is lacking, these trends are likely to apply to many LICs, including Tanzania.

The aim of this study is to compare the potential impact of two absolute risk approaches to define medication eligibility: (i) the WHO approach (risk threshold 10–19.9%) and (ii) the risk threshold differentiated by age. In both cases, we assume budgets to be constant (exogenous) and limited. Both alternatives are compared against (iii) a baseline scenario of no medical CVD prevention and (iv) a base-case scenario identical to the ESC approach (risk threshold ≥5–9.9%). We evaluate all four scenarios according to efficiency, inequality and the combination of efficiency and inequality.

1.3. Analytical framework

Health maximization and fair distribution are key principles for priority setting in health care in a number of countries. Operationalizing the health maximization principle by quantifying the costs of an activity relative to its benefits, for example in cost-effectiveness analysis (CEA), is practiced in countries such as the UK and USA (NICE, 2014; Sullivan et al., 2009), and also by the WHO through the CHOICE project (CHOosing Interventions that are Cost-Effective) (World Health Organization, 2014a). The health maximization principle has been criticized for ignoring the distribution of health benefits (World Health Organization, 2014b).

The distribution of health outcomes, on the other hand, is rarely quantified and is thus given less weight in actual priority setting (Norheim et al., 2014; Robberstad and Norheim, 2011; World Health Organization, 2014b). Distributional concerns can be motivated by two main arguments: egalitarianism (aversion to health inequality) and prioritarianism (a special concern for the worst off) (Bognar and Hirose, 2014; Brock and Wikler, 2006; Parfit, 1991, 1997; Persad et al., 2009). Both arguments value equality (however defined) but in different ways. For egalitarians, equality is directly important while for prioritarians, raising the position of the worst off will in many instances reduce inequality, but not always (Temkin, 1993). This implies that equality is valued indirectly in prioritarianism (Parfit, 1991, 1997). Issues of who are the worst off and how much priority they should be given continues to attract much attention in the literature (Bognar and Hirose, 2014; Brock and Wikler, 2006). Norwegian experts have justified their

preference for the differentiated risk threshold by age on both these distributive grounds (Norheim et al., 2011).

There are two distinct approaches to measuring health inequalities; overall (pure) inequality and social group inequality. The overall approach measures inequalities in the resulting distribution of health for all individuals in the general population, ignoring the determinants of health. The social group approach measures inequalities in the distribution of health according to some measure of socioeconomic status, e.g. income, wealth or education (Wagstaff and Doorslaerv, 2004). We are not considering socioeconomic status in this study and will therefore focus on overall health inequality. We do so because we did not have access to suitable data for modeling differential impacts by socioeconomic status.

It is now widely acknowledged that decision-makers may wish to combine concerns for health maximization with concerns for health distribution in the overall judgement of population health. Hence, consistent priority setting implies a need to quantify both types of outcomes to enable a trade-off between the two (Brock and Wikler, 2006; James et al., 2005; Norheim, 2014; Robberstad and Norheim, 2011; Williams and Cookson, 2006; World Health Organization, 2014b). Several proposals for taking into account both maximization and distributional concerns have been put forward. These include extending traditional cost-effectiveness analysis in two ways, by examining (i) financial risk protection effects as well as health effects, and (ii) the distribution of effects as well as total effects. This approach has been labelled "extended" cost-effectiveness analysis (Verguet et al., 2015). Another recent approach goes further and seeks to integrate distributional concerns into cost-effectiveness analysis (in what Asaria and colleagues term "distributional" cost-effectiveness analysis) through inequality indices and social welfare functions (Asaria et al., 2013). Integrating inequality aversion into a health-related social welfare function was first suggested by Anand and Wagstaff (Sudhir et al., 2001; Wagstaff, 2002b). The present study performs a distributional cost-effectiveness analysis using the Gini Index to quantify health inequality outcomes and the Achievement Index to integrate health inequality outcomes with total health outcomes.

2. Methodology

2.1. Analytical modeling

We used a simplified version of a previously published Markov model (Fig. 1) constructed in TreeAge Pro 2014 to analyze a closed hypothetical Tanzanian cohort of individuals having no previous history of MI or stroke (Ngalesoni et al., 2016).

The Markov analysis was run separately for the cohort of individuals having the three different CVD risk levels (low, moderate and high). For simplicity we choose to omit the very high CVD risk level. Each sub-cohort entered the six-state model ("no previous MI or stroke", "history of MI", "history of mild stroke", "history of moderate stroke", "history of severe stroke" and "death") at the age of 40 years and transited between the different health states in annual cycles according to age-specific risks for MI and stroke and depending on the risk reduction from medical interventions following each of the four CVD preventive scenarios analyzed (see Fig. 2).

All model inputs (costs, effectiveness, disability weights and other transition probabilities) were based on two previous papers on the cost and CEA of medical preventive strategies for CVD in Tanzania. Briefly, the cost estimates were estimated in the Tanzanian financial year 2011/2012 following a "narrow" societal perspective whereby only healthcare provider and patient costs were included. The other model inputs were extracted from relevant literature (Ngalesoni et al., 2014, 2016). Additional information on the number of Tanzanians with low, moderate and high CVD risk levels was required to estimate the total costs and health outcomes (CVD deaths) for each of the CVD preventive approaches analyzed. We applied the CVD risk level distribution for Africa region E reported in the WHO prevention of CVD guidelines (World Health Organization, 2007) to the Tanzanian population according to recent census data (National Bureau of Statistics Tanzania, 2013) to obtain such figures. These are presented in Table A.3 under Appendix 3. A time horizon of 40 years was applied, after which only a negligible proportion of the cohort was still alive.

Model outputs, i.e. total costs and CVD deaths, were then extracted from the Markov analysis output at the end of all cycles across the three CVD risk levels following the baseline, WHO, differentiated risk threshold and ESC approaches. Since we are comparing the WHO and the differentiated risk threshold by age approaches, assuming a constant and limited budget, we slightly reduced the coverage level of medical CVD prevention management following the differentiated risk threshold approach from the assumed 100% to about 84% so that the costs of these two approaches are equalized.

2.2. Baseline approach

For the baseline approach, no medical prevention is provided for any of the three CVD risk levels analyzed. This scenario almost resembles the current situation in Tanzania, where preventive services to individuals at risk are not systematically provided to the population. In the analysis of this approach, the three CVD risk level cohorts transit through the model with no adjustments to their risk of MI and stroke since no medical intervention is provided (light grey area on Fig. 2).

2.3. WHO approach (risk threshold 10–19.9%)

For the WHO approach, the cohort of low CVD risk (risk threshold <9.9%) transits through the model with their risk of MI and stroke remaining unadjusted (grey area in Fig. 2). The risks of disease (MI and stroke) for moderate and high CVD risk cohorts (risk threshold of 10–19.9% and 20–29.9% respectively) were adjusted according to the efficacy of the drug combinations which had the most favorable incremental cost-effectiveness ratio (ICER) from previous work on CEA of medical strategies to prevent CVD in Tanzania (Ngalesoni et al., 2016) (dark grey areas in Fig. 2 and Table 1).

2.4. Differentiated risk threshold by age

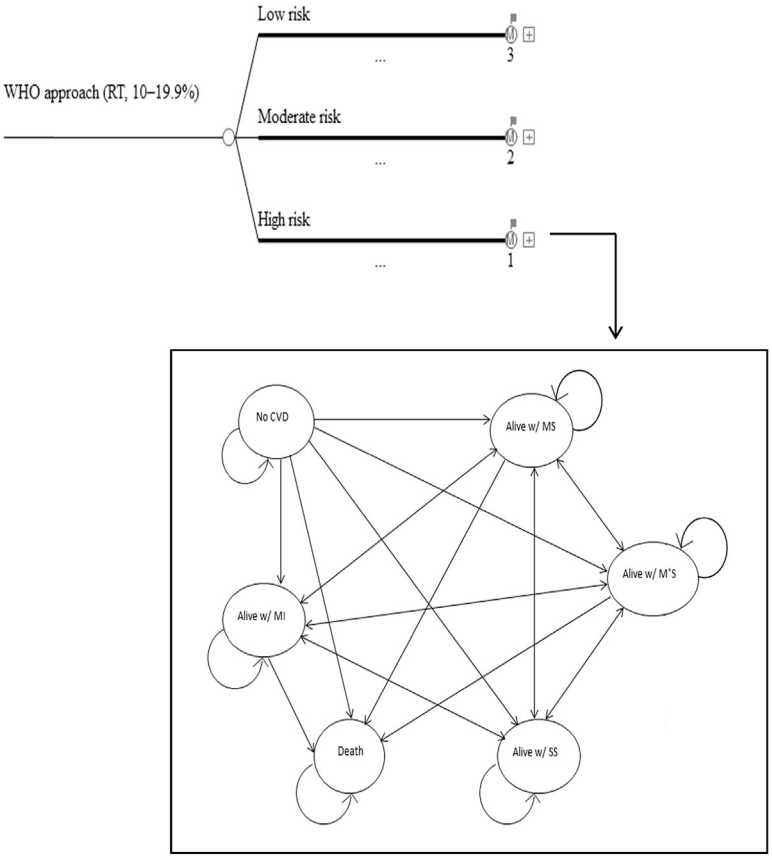
For this approach we applied different risk thresholds to different age groups such that medical preventive interventions are provided to:

- 40–49 years: if risk threshold is $\geq$ 5–9.9%
- 50–69 years: if risk threshold is $\geq$ 10–19.9%
- 70–79 years: if risk threshold is $\geq$ 20–29.9%

This means that the 40–49 year olds transited the model with their risk of disease adjusted by the most cost-effective medical interventions (see Table 1). For the 50–69 and 70–79 year olds, risk thresholds of $\geq$10–19.9% and $\geq$20–29.9%, respectively, were required before risks were adjusted medically in our model (light grey areas in Fig. 2).

2.5. ESC approach (risk threshold $\geq$ 5–9.9%)

For this approach, we assumed a base-case scenario in which Tanzania is willing to pay more than one GDP per capita for a unit of health gain such that it would become "very cost-effective" to treat all individuals with 10-year risk of a CVD event (risk threshold) equal to or above 5%. In examining the equity impact of this



1, 2, 3 represent three different clone masters; RT=risk threshold; CVD=cardiovascular disease; w/=with; MI=myocardial infarction; MS=mild stroke; M*S=moderate stroke; SS=severe stroke.

Fig. 1. Simplified Markov model structure for WHO approach (risk threshold 10–19.9%).

approach, patients in the three CVD risk levels (dark grey area on Fig. 2) transit through the model with their risk of MI and stroke adjusted by efficacy of the medical interventions recommended for a particular CVD risk level in the previous cost-effectiveness study (Table 1) (Ngalesoni et al., 2016).

For the WHO, differentiated risk threshold and ESC approaches, we assume that the CVD prediction charts rightly classify cohorts into correct risk level category in accordance to their CVD risk factors.

2.6. Equity analysis

2.6.1. Outcomes of interest

We analyzed equity and efficiency according to three outcomes of interest. These were: (i) life expectancy at age 40, as a proxy of efficiency; (ii) inequality in life expectancy at age 40, using the Gini coefficient; and (iii) achievement index, which is a proxy combining concern for both efficiency and inequality. From this point onwards, we will use life expectancy to refer to life expectancy at age 40.

2.7. Life expectancy

Life expectancies were derived from the age-specific CVD deaths obtained from the Markov analysis.

	Baseline approach			ESC approach (risk threshold ≥5–9.9%)			WHO approach (risk threshold 10–19.9%)			Differentiated risk threshold by age		
	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High
40-49	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%
50-59	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%
60-69	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%
70-79	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%	λ=5%	λ=15%	λ=25%

Low=low CVD risk level (10-year risk of a CVD event of <9.9%); Mod=moderate CVD risk level (10-year risk of a CVD event of 10–19.9%); High=high CVD risk level (10-year risk of a CVD event of 20–29.9%); λ=Average 10-year risk of a CVD event for a particular CVD risk level; No CVD primary prevention by medical management; CVD primary prevention intervention

Fig. 2. Risk threshold approaches to medical prevention of cardiovascular diseases.

Table 1
Drug combination used (*) in applying different risk thresholds to medical prevention of CVD.

Strategy	Cost	Incr. cost	Effectiveness	Incr. effectiveness	ICER
Low risk					
No treatment	461		0.00		
ACEI_Diu*	1005	544	0.41	0.41	1347
ACEI_Diu_Sta	1259	254	0.49	0.08	3175
Moderate risk					
No treatment	1516		0.00		
ACEI_Diu*	1683	167	1.02	1.02	164
ACEI_Diu_Sta	1827	144	1.28	0.26	554
High risk					
No treatment	1695		0.00		
ACEI_CCB_Diu*	2240	545	1.56	1.56	349
ACEI_CCB_Diu_Sta	2404	164	1.83	0.27	607

Incr = Incremental; ICER=Incremental cost-effectiveness ratio; ACEI = Angiotensin converting enzyme inhibitor; Diu = Thiazide diuretic; Sta = Statin; CCB=Calcium channel blockers; ASA = Soluble aspirin; Interventions are said to be "very cost-effective" if their ICER ≤ some willingness to pay value (assumed to be US$610, which is Tanzania's Gross Domestic Product (GDP) per capita for 2012). These results are based on a paper on cost-effectiveness analysis of medical interventions in Tanzania (Ngalesoni et al., 2016).

2.7.1. Gini coefficient

For each of the four medical CVD preventive scenarios analyzed, we employed Wagstaff's standard Gini coefficient (Wagstaff, 2002b) using the formula below:

$$G = 1 - \frac{\sum_{i=1}^{n}\left(R_i^2 - (R_i - 1)^2\right)h_i}{n^2\mu(h)}$$

where n is the subset of the at-risk population that experienced CVD death, $\mu(h)$ is the average health of this population expressed as average life expectancy, h_i is the life expectancy for individual i and R_i is the relative rank of the ith individual. The coefficient is bound between 0 and 1, where 0 describes perfect equality and 1 describes perfect inequality (Wagstaff, 2002b).

2.7.2. Achievement index

We adopted Wagstaff's proposition of integrating aversion to inequality into a social welfare function framework in a measure he calls the achievement index (A) (Wagstaff, 2002b). The achievement index can simply be understood as health adjusted for inequality or, in our case, inequality-adjusted life expectancy. This was calculated as follows:

$$A = \frac{\sum_{i=1}^{n}\left(R_i^v - (R_i - 1)^v\right)h_i}{n^v} = \mu(h)(1 - G)$$

In which *hi* reflects ex post estimates of life expectancy from our Markov model, and parameter v represents the degree of overall equality aversion. Values > 1 indicate preferences in favor of giving more weight to the worse-off (lower ranked) individuals compared to better-off (higher ranked) individuals. In this work, we assume $v = 2$.

3. Ethical statement

Ethical clearance was provided by the Ethical Review Committee of the Tanzania National Institute of Medical Research with Ref. No. NIMR/HQ/R.8 a/Vol. IX/1364. Respondents from the health facilities involved were asked for their consent to participate in the study and written permission was obtained prior to the interviews.

4. Results

4.1. Number of deaths

The number of annual CVD deaths was found to increase as the cohort grows older, irrespective of risk approach. When the two absolute risk approaches are compared, the WHO approach resulted in the highest mortality amongst young age groups and lowest mortality amongst old age groups compared to the differentiated risk threshold by age approach (Fig. 3).

It is interesting to note that the pattern of annual CVD deaths following the differentiated risk threshold by age approach mimics the policy it resembles at each age interval. For age group 40–49, the number of deaths is somewhat similar to the ESC approach where medical CVD prevention is provided in a non-discriminatory way to all with risk threshold ≥5%. In age group 50–69, the mortality pattern runs parallel to that of the WHO approach, while at the oldest age groups, where higher risk thresholds are required for the initiation of CVD prevention management, the number of CVD deaths slopes up towards the baseline approach of no medical prevention for anyone (Fig. 3).

4.2. Gini coefficient, life expectancy, achievement index and total cost

The life expectancy at 40 resulting from no medical CVD prevention (baseline approach) is 23.3 years, which is the lowest of the four preventive scenarios analyzed. This approach is also accompanied by the highest Gini coefficient and lowest achievement index. Even though no medical intervention is modeled, the total cost of this approach is US$42 million, since we assume full access to CVD prevention (although for this scenario no CVD prevention is provided) and management. The cost therefore reflects the CVD management costs incurred when part of the cohort develops CVD.

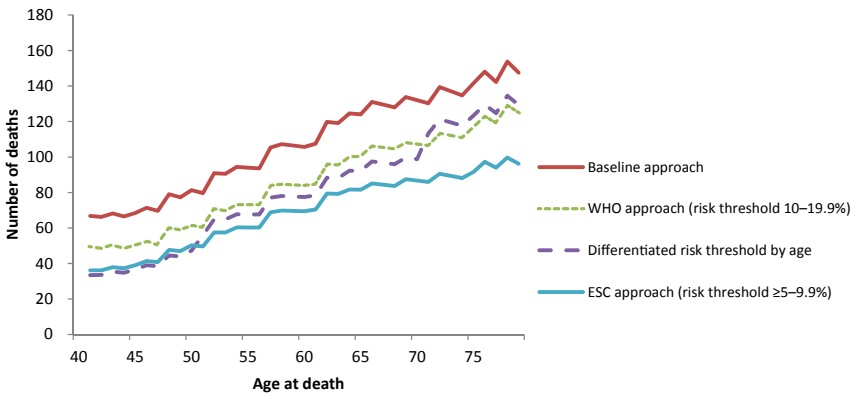


Fig. 3. Annual number of deaths when different risk thresholds for CVD medical prevention are applied.

Table 2
Gini index, life expectancy, achievement index and total costs of different risk threshold approaches for medical prevention of CVD.

	LE at 40	Gini index	A-index	Total costs (000′US$)	No. Treated
Baseline approach	23.3	0.266	17.1	41,700	
WHO approach (RT, 10–19.9%)	26.6	0.243	20.1	60,200	487,000
Differentiated risk threshold by age	28.3	0.216	22.2	60,200	567,000
ESC approach (RT, ≥ 5–9.9%)	29.2	0.211	23.0	77,700	1,275,000

LE = life expectancy at age 40 years; A = achievement; No = numbers; RT = risk threshold.

When the total costs of the two approaches, WHO and differentiated risk threshold by age, are the same, providing CVD prevention by applying the differentiated risk threshold is the best approach in terms of both efficiency (life expectancy at 40 of 28.3 years compared to 26.6 years) and in terms of equality (Gini coefficient 0.216 vs. 0.243), and consequently also when both efficiency and inequality are jointly considered (Table 2). There was no distributional conflict between these two approaches, since the approach that maximizes health is also the approach that distributed life expectancies most equitably.

While the ESC approach gave the highest life expectancy at the age of 40 (29.2 years compared with 26.6 years – WHO approach and 28.3 years – differentiated risk threshold approach), it was also the one that produced the most equitable distribution of health in terms of remaining life expectancy since its Gini coefficient was lower (0.211) compared to the WHO (0.243) and the differentiated risk threshold (0.216) approaches. This translates into this approach producing the highest achievement index (A = 23.0), followed by the differentiated risk threshold (A = 22.2) and lastly the WHO approach (A = 20.1). However, this approach comes with very high total costs of around US$78 million (Table 2).

4.3. Pairwise comparisons between the different CVD prevention approaches

Providing CVD prevention by differential risk threshold by age approach resulted in the least cost per life year gained compared to the baseline approach of no CVD medical prevention (CER = US$ 3,761,000 per LY). On the other hand, pairwise comparison between basing treatment threshold on ESC approach to CVD prevention following differentiated risk threshold approach yielded the highest cost per life year gained (CER = US$ 19,059,000 per LY) (Table 3).

The differentiated risk threshold approach was also the most cost-equitable approach compared to the baseline approach with cost per percentage Gini improvement of US$ 3,698,000. Even though WHO single risk approach had the second least cost per life year gained compared to the baseline approach, this approach yielded one of the highest cost per percentage Gini improvement of US$ 8,103,000 (Table 3).

In both instances differentiated risk threshold approach dominated the WHO single risk approach. With the cost of the two approaches designed to be the same, the former yielded more life years and percentage Gini improvement than the latter.

5. Discussion

In this work we have shown that the absolute risk approach by differentiated risk thresholds brings about more and fairer health compared to the absolute risk approach by single risk threshold recommended by the WHO when the total costs of the two approaches are the same. When compared with the baseline approach, differentiated risk threshold approach is the best in terms of life expectancy maximization and inequality reduction while WHO single risk threshold yielded higher cost per life year gained and cost per percentage Gini improvement respectively.

The paper builds upon the recommendations for CVD prevention in Norway, which proposes a shift from ESC guidelines to the application of a differentiated risk threshold by age. This work goes one step further by modeling the different risk threshold approaches and by explicitly estimating their equality impact. Nevertheless, some comparisons can be made with the results of the analysis exploring the potential implications of the Norwegian guidelines (Norheim, 2014). They showed that life years gained from primary medical prevention of CVD would be more equally distributed with the differentiated risk threshold approach compared to the ESC's single risk threshold approach. In this work, we found similar results when comparing the differentiated risk threshold approach to the WHO's single risk threshold approach. However, these two works differ in some important respects. Firstly, the Norwegian recommendations use different risk threshold cut-offs of 1%, 5% and 10% for 0–49, 0–59 and 0–69 age groups, respectively, for their differentiated risk threshold approach and, secondly, their distribution of CVD risk levels was based on country-specific data.

The achievement index makes equity-efficiency trade-offs explicit. The formulation hinges on the value of the parameter v, which reflects the relative weight that a decision-maker or analyst assigns to the health of the different groups. In most cases, the value of v is unknown. For illustrative purposes, and following what is mostly used in the literature, we set the parameter $v = 2$. A sensitivity analysis using alternative inequality aversion parameters would be possible, and is in general advised (Johansson and Norheim, 2011; O'Donnell Owen et al., 2007; Wagstaff, 2002a). However, this was not necessary in this case, since the differentiated threshold approach is dominating the other alternatives in terms of efficiency and equity impact, therefore different inequality aversion parameters would not change the main result. If our results had shown a distributive conflict between maximization and equity, such a sensitivity analysis would have been obligatory.

Table 3
Pairwise comparisons of the different risk threshold approaches for medical prevention of CVD.

	Incr. TC (000′ US$)	Incr. LY gained	% Gini improvement	Cost/LY gained (000' US$)	Cost/% Gini improvement (000' US$)
WHO versus Baseline	18,542	3.22	2.29	5760	8103
DRT versus Baseline	18,542	4.93	5.01	3761	3698
ESC versus Baseline	35,966	5.84	5.47	6154	6577
DRT versus WHO	0	1.71	2.73	dominant	dominant
ESC versus WHO	17,425	2.63	3.18	6636	5478
ESC versus DRT	17,425	0.91	0.45	19,059	38,330

Incr = Incremental; TC = Total costs; LY = Life year; WHO= WHO approach (RT, 10–19.9%); Baseline = Baseline approach of no medical CVD prevention; DRT = Differentiated risk threshold by age; ESC = ESC approach (RT, ≥ 5–9.9%); vs = versus.

Nevertheless, empirical studies from Tanzania are needed to inform the choice of *v*, because different populations are likely to have different rates of trade-off between inequality and efficiency.

In this work we use a univariate approach to inequality analysis, which has the advantages of providing an overall picture of inequalities in age at death when different CVD management risk thresholds are applied and is likely to be comparable if similar studies are undertaken in other settings (Asada, 2013). However, determining changes in inequalities between social groups is important in this setting, in which policies usually aim for socioeconomic redistribution (James et al., 2005). Combining univariate and bivariate analysis would be an interesting next step (Asada, 2013; Fleurbaey and Schokkaert, 2009).

This study has several limitations. Firstly, even though we showed that primary prevention of CVD in most cases is cost-effective in Tanzania (Ngalesoni et al., 2016), the different approaches in their implementation have different cost implications. When comparing these options with different costs, for instance WHO approach versus baseline approach or differentiated risk threshold approach versus the ESC approach, one would ideally take into account not only the health inequality impact of health benefits (included in this analysis) but also the health inequality impact of other possible uses of the given budget. Secondly, the analysis is limited to overall inequality, without disentangling fair from unfair inequality. Such considerations would have required additional information on socioeconomic statuses, individual responsibility and so on. Thirdly, due to data limitations we made no adjustment for impacts on health-related quality of life and focused only on life expectancy. Fourly, our assumption of no medical CVD prevention for the baseline approach—even though it may resemble current situation in Tanzania—may not be entirely true for the time horizon of 40 years considered in this work. Ideally, current and future trends in privately funded CVD prevention could have been included to inform a more realistic scenario. Fifth, we relied on the WHO's Africa region E distribution of CVD risk levels—due to a lack of country-specific data—which are estimated from countries with significant diversity in terms of demographic, epidemiological, socio-economic and policy contexts. The results should therefore be interpreted with caution when used in this setting. Nevertheless, we believe that the high prevalence of CVD risk factors currently observed in Tanzania is not very different from the situation in other SSA contexts. Lastly, our modeling of total cost did not follow standard guidelines for a budget impact analysis (Mauskopf et al., 2007; Sullivan et al., 2014). We relied on a simplified approach for estimating the total costs, which may not reflect all costs or economies of scale, accurately. More work needs to be done on implementation costs before policy implications can be drawn.

6. Conclusions

This work illustrates that evidence on costs and outcomes within a disease area in a low-resource setting can be used to estimate impact on and distribution of life expectancy using standard summary measures of population health. Under constant and limited budgets, and if concerns for efficiency and equal distribution are both important, then the differentiated risk threshold by age is the better approach compared to the single risk threshold of 10–19.9% recommended by the World Health Organization guidelines. However, more research is required on the country-specific distribution of cardiovascular risk levels and a budget impact analysis to assess the feasibility of its implementation.

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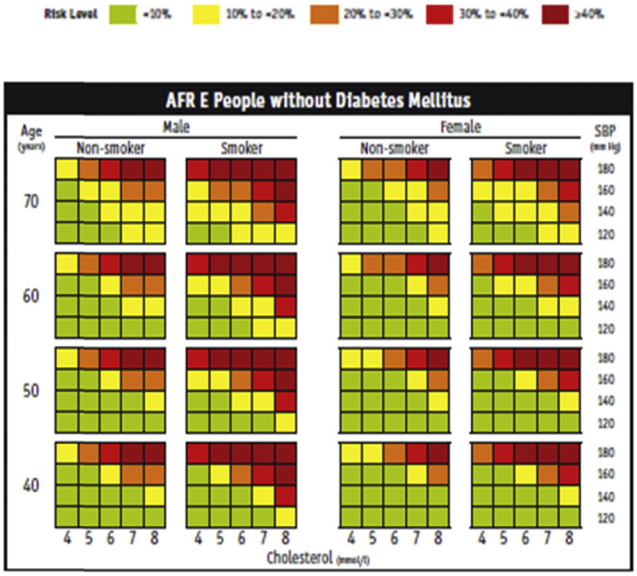
Appendices

Appendix 1

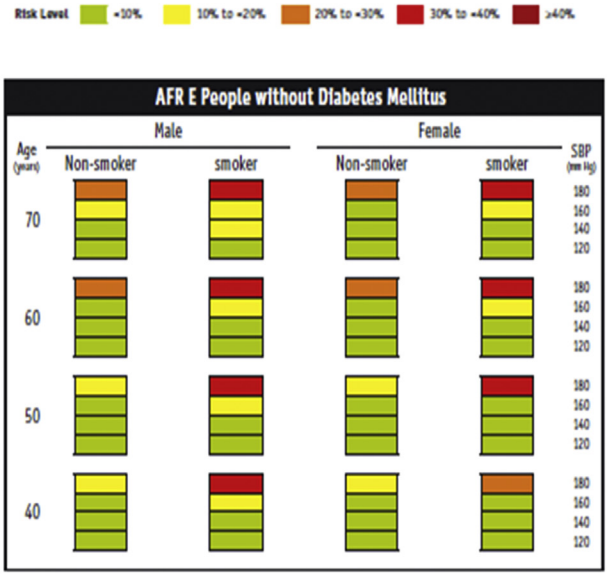
WHO/ISH risk prediction chart for AFR E. 10-year risk of a cardiovascular event by gender, age, systolic blood pressure and smoking status in settings where blood cholesterol can (Appendix 1a) and cannot (Appendix 1b) be measured.

Reproduced with permission from WHO Prevention of Cardiovascular Disease, *Pocket Guidelines for Assessment and Management of Cardiovascular Risk*, reference: (World Health Organization, 2007)

a

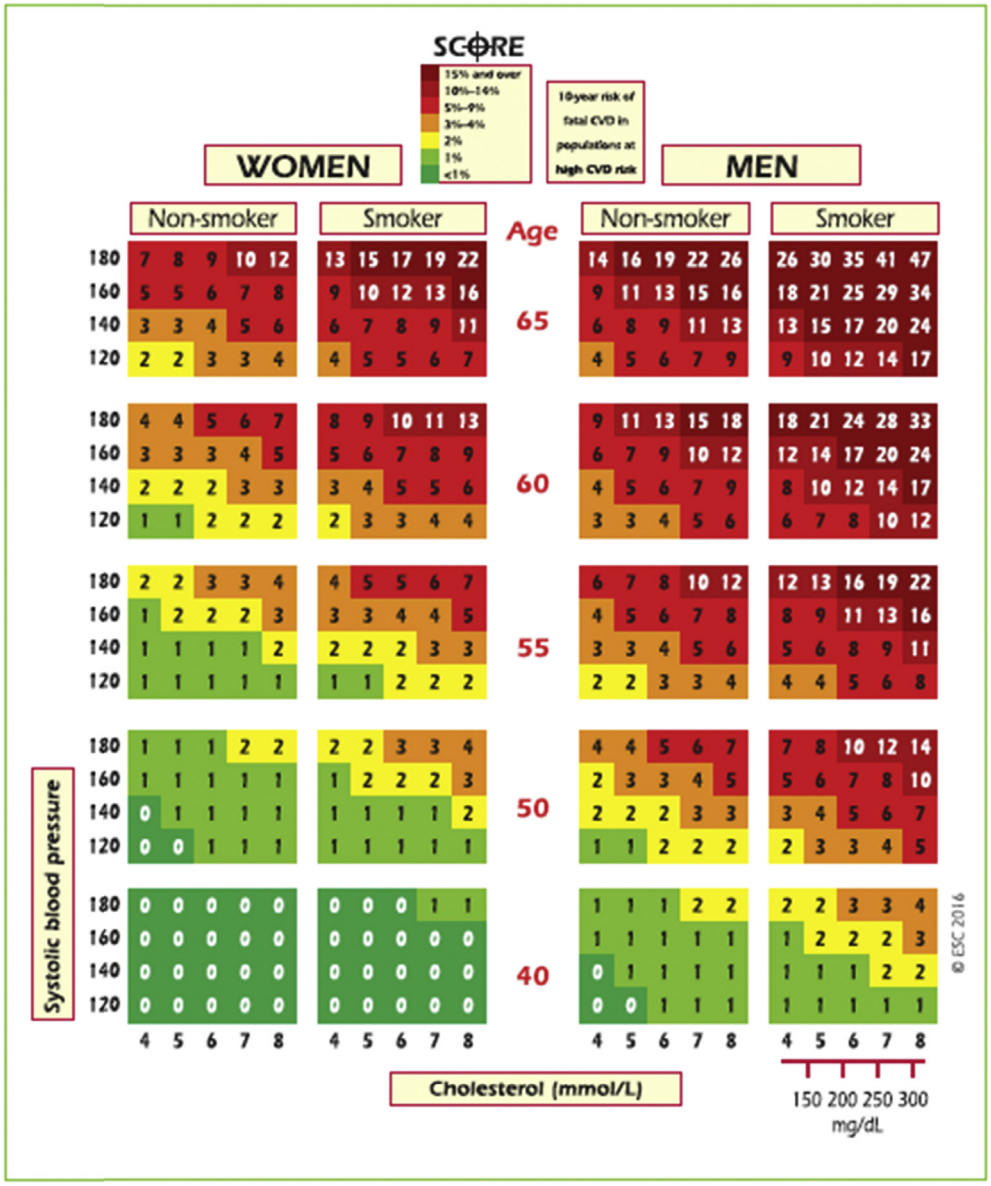


b



Appendix 2

SCORE chart: 10-year risk of fatal cardiovascular disease (CVD) in countries at high CVD risk based on the following risk factors: age, sex, smoking, systolic blood pressure, and total cholesterol.



Reproduced from Piepoli MF, Hoes AW, Agewall S et al., 2016. European Guidelines on cardiovascular disease prevention in clinical practice. European Heart Journal Aug 2016, 37 (29) 2315–2381; http://dx.doi.org/10.1093/eurheartj/ehw106 with permission of Oxford University Press (UK) (c) European Society of Cardiology, www.escardio.org/

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Appendix 3

Table A.3. CVD risk level distribution for WHO Africa region E and Tanzania population size based on census 2012

CVD risk level*	40–49	50–59	60–69	70+	Source
CVD risk level distribution					
Low (≥5–9.9%)	0.9538	0.8333	0.6890	0.5683	(World Health Organization, 2007)
Moderate (10–19.9%)	0.0422	0.1193	0.1148	0.1842	
High (20–29.9%)	0.0271	0.0608	0.1121	0.1394	
Estimated number of individuals at each level of CVD risk					
Low (≥5–9.9%)	415,529	205,284	110,991	56,663	(National Bureau of Statistics Tanzania, 2013)
Moderate (10–19.9%)	73,539	117,558	73,973	73,464	
High (20–29.9%)	24,107	42,081	44,462	37,488	

*Index cohort characteristics for low CVD risk level (female, SBP of 120–139 mmHg, non-smoker, total cholesterol level of 4 mmol, non-diabetic); moderate CVD risk level (female, SBP of 150–169 mmHg, smoker, total cholesterol level of 6 mmol for age groups 40–49 and 50–59 and 5 mmol for age groups 60–69 and 70+, non-diabetic); high CVD risk level (male, SBP of 150–169 mmHg, non-smoker, total cholesterol level of ≥8 mmol, non-diabetic); SBP = systolic blood pressure.

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