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Reframing Non-Communicable Diseases and Injuries for equity in limited resource settings in the context of Universal Health Coverage in Kenya

Mwangi, Kibachio Joseph Morris M.

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**UNIVERSITÉ
DE GENÈVE**

FACULTÉ DE MÉDECINE

Institut de santé globale

Faculté de Médecine,

Département de Médecine Sociale et
Préventive,

Institut de Santé Globale

Thèse préparée sous la direction du Professeur Idris Guessous

**RECADRE LES MALADIES NON TRANSMISSIBLES ET LES BLESSURES POUR L'ÉQUITÉ DANS
LES MILIEUX À RESSOURCES LIMITÉES DANS LE CONTEXTE DE LA COUVERTURE
SANITAIRE UNIVERSELLE AU KENYA**

Thèse

présentée à la Faculté de Médecine

de l'Université de Genève

pour obtenir le grade de Docteur en Sciences Biomédicales , Mention Santé Globale
par

Kibachio Joseph MWANGI

de

Kenya

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“May this work immortalize Elizabeth Wairimu; my Mother,
who sacrificed for me to live and to go to school”

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Kenya

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“Asanteni sana; Mungu awabariki”

List of Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
AOR	Adjusted Odds Ratios
APHRC	Africa Population Health Research Center
COPD	Chronic Obstructive Pulmonary Disease
CVD	Cardiovascular Disease
DALYs	Disability-Adjusted Life Years
DCP3	Disease Control Priorities 3
DHS	Demographic and Health Survey
DNA	Deoxyribonucleic Acid
GBD	Global Burden of Disease
GNI	Gross National Income
GoK	Government of Kenya
HDSS	Health and Demographic Surveillance System
HIV	Human Immunodeficiency Virus
HPV	Human Papillomavirus
HSSP	Health Sector Strategic Plan
ICC	Inter-sectoral Collaborating Committee
KDHS	Kenya Demographic and Health Survey
KEMRI	Kenya Medical Research Institute
KEPH	Kenya Essential Package for Health
KMoH	Kenya Ministry of Health
KSh	Kenyan Shilling
LMIC	Low and Middle-income Countries
MDG	Millennium Development Goals
MPI	Multidimensional Poverty Index
MTNT	Maladies Non Transmissibles et Traumatismes
NCDIs	Non-Communicable Diseases and Injuries
NCDs	Non-Communicable Diseases
NEML	National Essential Medicines List
NHA	National Health Accounts
PHC	Primary Health Care
PPP	Purchasing Power Parity
SARA	Service Availability and Readiness Assessment
SDG	Sustainable Development Goals
SES	Social Economic Status
SSPH	Swiss School of Public Health
THE	Total Health Expenditure
UHC	Universal Health Coverage
UNGA	UN General Assembly
UNIGE	University of Geneva
USD	United States Dollar
WHA	World Health Assembly
WHO	World Health Organization
WHO STEPS	WHO STEPwise Approach to Surveillance
YLD	Years Lived with Disability
YLL	Years of Life Lost

List of Publications, Submitted Manuscripts & Oral Communications

I. Scientific articles published in peer reviewed journals in which the candidate is the first author, and the supervisor is a co-author,

1. Mwangi, K., Gathecha, G., Nyamongo, M., Kimaiyo, S., Kamano, J., Bukachi, F., Odhiambo, F., Meme, H., Abubakar, H., Mwangi, N., Nato, J., Oti, S., Kyobutungi, C., Wamukoya, M., Mohamed, S.F., Wanyonyi, E., Ali, Z., Nyanjau, L., Nganga, A., Kiptui, D., Karagu, A., Nyangasi, M., Mwenda, V., Mwangi, M., Mulaki, A., Mwai, D., Waweru, P., Anyona, M., Masibo, P., Beran, D., Guessous, I., Coates, M., Bukhman, G. and Gupta, N., 2021. **Reframing Non-Communicable Diseases and Injuries for Equity in the Era of Universal Health Coverage: Findings and Recommendations from the Kenya NCDI Poverty Commission.** *Annals of Global Health*, 87(1), p.3. <https://www.annalsofglobalhealth.org/articles/10.5334/aogh.3085>
2. Mwangi KJ, Mwenda V, Gathecha G, Beran D, Guessous I, Ombiro O, Ndegwa Z, Masibo P. **Socio-economic and demographic determinants of non-communicable diseases in Kenya: a secondary analysis of the Kenya stepwise survey.** *Pan Afr Med J.* 2020 Dec 16;37:351. PMC7992900 <https://www.panafrican-med-journal.com/content/article/37/351/full>
3. Kibachio, J., Mwenda, V., Ombiro, O., Kamano, J. H., Perez-Guzman, P. N., Mutai, K. K., Guessous, I., Beran, D., Kasaie, P., Weir, B., Beecroft, B., Kilonzo, N., Kupfer, L., & Smit, M (2020). **Recommendations for the use of mathematical modelling to support decision-making on integration of non-communicable diseases into HIV care.** *Journal of the International AIDS Society*, 23 Suppl 1(Suppl 1), e25505. <https://doi.org/10.1002/jia2.25505>

II. Supplementary articles related to the thesis in which the candidate is an author and affiliated to the institute of Global Health; Faculty of Medicine, University of Geneva, Switzerland.

1. Geldsetzer P, Manne-Goehler J, Marcus ME, Ebert C, Zhumadilov Z, Wesseh CS, Tsabedze L, Supiyev A, Sturua L, Bahendeka SK, Sibai AM, Quesnel-Crooks S, Norov B, Mwangi KJ, Mwalim O, Wong-McClure R, Mayige MT, Martins JS, Lunet N, Labadarios D, Karki KB, Kagaruki GB, Jorgensen JMA, Hwalla NC, Houinato D, Houehanou C, Msaidié M, Guwatudde D, Gurung MS, Gathecha G, Dorobantu M, Damasceno A, Bovet P, Bicaba BW, Aryal KK, Andall-Brereton G, Agoudavi K, Stokes A, Davies JI, Bärnighausen T, Atun R, Vollmer S, Jaacks LM. **The state of hypertension care in 44 low-income and middle-income countries: a cross-sectional study of nationally representative individual-level data from 1·1 million adults.** *Lancet.* 2019 Aug 24;394(10199):652-662. doi: 10.1016/S0140-6736(19)30955-9. Epub 2019 Jul 18. PMID: 31327566
2. Lemp JM, De Neve JW, Bussmann H, Chen S, Manne-Goehler J, Theilmann M, Marcus ME, Ebert C, Probst C, Tsabedze-Sibanyoni L, Sturua L, Kibachio JM, Moghaddam SS, Martins JS, Houinato D, Houehanou C, Gurung MS, Gathecha G, Farzadfar F, Dryden-Peterson S, Davies JI, Atun R, Vollmer S, Bärnighausen T, Geldsetzer P. **Lifetime Prevalence of Cervical Cancer Screening in 55 Low- and Middle-Income Countries.** *JAMA.* 2020 Oct 20;324(15):1532-1542. doi: 10.1001/jama.2020.16244. PMID: 33079153; PMCID: PMC7576410
3. Wekesah FM, Nyanjau L, Kibachio J, Mutua MK, Mohamed SF, Grobbee DE, Klipstein-Grobusch K, Ngaruiya C, Haregu TN, Asiki G, Kyobutungi CK. **Individual and household level factors associated with presence of multiple non-communicable disease risk factors in Kenyan adults.** *BMC Public Health.* 2018 Nov 7;18(Suppl 3):1220. doi: 10.1186/s12889-018-6055-8. PMID: 30400905; PMCID: PMC6219015

4. Bukhman G, Mocumbi AO, Atun R, et al. **The Lancet NCDI Poverty Commission: bridging a gap in universal health coverage for the poorest billion.** *Lancet*.2020;396(10256):991-1044.doi:10.1016/S0140-6736(20)31907-3 **(I was part of the publication as The Lancet NCDI Poverty Commission study group that includes the co-chairs and coordinators of the first 11 countries to initiate National NCDI Poverty Commissions, Groups and Consortia.)*
5. Matanje Mwagomba BL, Ameh S, Bongomin P, Juma PA, MacKenzie RK, Kyobutungi C, Lukhele N, Mwangi KJM, Amberbir A, Klipstein-Grobusch K, Gómez-Olivé FX, Berman J. **Opportunities and challenges for evidence-informed HIV-noncommunicable disease integrated care policies and programs: lessons from Malawi, South Africa, Swaziland and Kenya.** *AIDS*. 2018 Jul 1;32 Suppl 1:S21-S32. doi: 10.1097/QAD.0000000000001885. PMID: 29952787
6. Seiglie JA, Marcus ME, Ebert C, Prodromidis N, Geldsetzer P, Theilmann M, Agoudavi K, Andall-Brereton G, Aryal KK, Bicaba BW, Bovet P, Brian G, Dorobantu M, Gathecha G, Gurung MS, Guwatudde D, Msaidié M, Houehanou C, Houinato D, Jorgensen JMA, Kagaruki GB, Karki KB, Labadarios D, Martins JS, Mayige MT, Wong-McClure R, Mwangi JK, Mwalim O, Norov B, Quesnel-Crooks S, Silver BK, Sturua L, Tsabedze L, Wesseh CS, Stokes A, Atun R, Davies JI, Vollmer S, Bärnighausen TW, Jaacks LM, Meigs JB, Wexler DJ, Manne-Goehler J. **Diabetes Prevalence and Its Relationship With Education, Wealth, and BMI in 29 Low- and Middle-Income Countries.** *Diabetes Care*. 2020 Apr;43(4):767-775. doi: 10.2337/dc19-1782. Epub 2020 Feb 12. PMID: 32051243; PMCID: PMC7085810
7. Smit M, Perez-Guzman PN, Mutai KK, Cassidy R, Kibachio J, Kilonzo N, Hallett TB. **Mapping the Current and Future Noncommunicable Disease Burden in Kenya by Human Immunodeficiency Virus Status: A Modeling Study.** *Clin Infect Dis*. 2020 Nov 5;71(8):1864-1873. doi: 10.1093/cid/ciz1103. PMID: 31734688.
8. Mwenda V, Mwangi M, Nyanjau L, Gichu M, Kyobutungi C, Kibachio J. **Dietary risk factors for non-communicable diseases in Kenya: findings of the STEPS survey, 2015.** *BMC Public Health*. 2018 Nov 7;18(Suppl 3):1218. doi: 10.1186/s12889-018-6060-y. PMID: 30400904; PMCID: PMC6219002.
9. Teufel F, Seiglie JA, Geldsetzer P, Theilmann M, Marcus ME, Ebert C, Arboleda WAL, Agoudavi K, Andall-Brereton G, Aryal KK, Bicaba BW, Brian G, Bovet P, Dorobantu M, Gurung MS, Guwatudde D, Houehanou C, Houinato D, Jorgensen JMA, Kagaruki GB, Karki KB, Labadarios D, Martins JS, Mayige MT, McClure RW, Mwangi JK, Mwalim O, Norov B, Crooks S, Farzadfar F, Moghaddam SS, Silver BK, Sturua L, Wesseh CS, Stokes AC, Essien UR, De Neve JW, Atun R, Davies JI, Vollmer S, Bärnighausen TW, Ali MK, Meigs JB, Wexler DJ, Manne-Goehler J. **Body-mass index and diabetes risk in 57 low-income and middle-income countries: a cross-sectional study of nationally representative, individual-level data in 685 616 adults.** *Lancet*. 2021 Jul 17;398(10296): 238-248.DOI: [https://doi.org/10.1016/S0140-6736\(21\)00844-8](https://doi.org/10.1016/S0140-6736(21)00844-8) PMID: 34274065.

III. Oral presentations made on parts of this thesis work:

1. Participated in the 2018 Swiss School of Public Health SSPH+ Science Flash Talk Award at the Geneva Health Forum (GHF) on 10 April 2018 and made a presentation on the thesis work (see annexed certificate and ECT credit confirmation)
2. **The impact of the NCDI Poverty Lancet Commission report on more inclusive, pro-poor NCD policies in Kenya.** I Made a presentation on part of the thesis pitching on the policy utility of the work done with the lancet poverty commission towards reframing non-communicable diseases and injuries for equity in the era of UHC in Kenya.
 - o Recording for the high-level Launch of the Lancet poverty Commission on vimeo.com on twitter. <https://t.co/KhV18iuOnd?amp=1>

Abstract in English

Background:

Non-Communicable Diseases and injuries (NCDs) are the leading causes of morbidity and mortality worldwide, with projections of even more burden by 2030 especially from low and middle-income countries. NCDs are becoming a major public health concern with significant social and economic implications in terms of health care-needs, lost productivity and premature death and are thus a serious setback to the attainment of social, health and economic targets. This thesis set out to establish the burden of NCDs and Injuries in Kenya, their correlation to socioeconomic determinants and the contribution of poverty as a driver of their causation and outcome. It further looked at the health system readiness, availability, effectiveness and coverage of the current approach and recommended a package of interventions for halting and reversing the NCDI burden in Kenya in the context of Universal Health Coverage (UHC).

Methods:

The burden of NCDs was determined using desk reviews of published literature, estimates from the Global Burden of Disease Study and secondary analysis of the Kenya WHO STEP survey for non-communicable disease (NCD) risk factors which is the WHO-recommended framework for NCD surveillance. The GBD 2016 study was utilized to model and estimate prevalence, disability-adjusted life years (DALYs) and proportion of total deaths from specific NCDs and injuries. The Kenya Demographic and Health Survey and 2 Health and Demographic Surveillance System (HDSS) were used to determine causes of death, overall death rates due to NCDs and to calculate a comparative socioeconomic status index. Data on national health expenditures were extracted from the Kenya National Health Accounts 2015/2016.

Baseline availability of NCDI services was estimated using the 2013 Kenya Service Availability and Readiness Assessment (SARA) survey. Priority conditions were selected based on the overall health impact, severity in terms of premature mortality, disability caused, comparative inequity caused and the prevailing national priorities. A package of cost-effective interventions costed for low-income countries to achieve UHC for NCDs and injuries was drawn from the Disease Control and Priorities 3 (DCP3) study group. Following a policy recommendation from this work for integration of NCDs into existing primary care platforms such as HIV, TB and maternal health, the feasibility of using mathematical modelling to support decision-making on integration of NCDs and HIV/AIDS was evaluated.

Results:

There is a high burden of NCDs accounting for 37% of the disease burden in DALYs in Kenya. More than half (53%) of the NCD DALYs and 72% of injury DALYs occur before the age of 40. Of all DALYs from NCDs, 67% were however related to conditions other than the four NCDs highlighted in the WHO NCD Global Action Plan. The poorest wealth quintiles experienced a substantially higher death rate from NCDs and had lower access to diagnosis and NCD-related health services.

There was a 23.2% reduction in household income in households with NCD relative to households affected by communicable diseases. Of households experiencing NCDs, 29.9% of those in the lowest quintile experienced catastrophic expenditures (>30% of total household income), compared to 9.2% in the highest income quintile. Counties with a higher proportion of the population living in the poorest quintile had a lower mean number of tracer NCD medications and services ($r = -0.386$, $p = <0.01$). Fourteen conditions were recommended to build on the existing Kenya NCD Strategic Plan alongside a package of thirty-four interventions across the outpatient, inpatient, surgical, mental health, rehabilitation, and palliative care service in the UHC context at an estimated cost of USD 520,146,154 which represents an incremental investment of USD 11.97 per capita annually that will potentially avert 9,322 premature deaths annually by the year 2030.

Conclusions and perspectives

To halt and reverse the growing burden of NCDs in Kenya, policy makers must broaden their attention beyond the traditional NCD behavioural risk factors and embrace a more comprehensive approach with inclusive interventions across the life course as opportunities for prevention and control of NCDs exist in all cohorts of the human development and not only among the older persons.

While behavioural risk factors have a large attributable risk for NCDs and Injuries, poverty has a huge indirect role in the progression and outcome of these diseases in limited resource settings like Kenya. A whole of government approach is required as some of the determinants of NCDs like poverty fall outside the direct control of the health sector. As NCD systems are poorly funded, integrating some elements of their prevention and control into other primary care platforms like HIV will create synergies that will improve access and outcome. To support decision making on scale and what components to integrate, the use of mathematical modelling is highly recommended drawing on the HIV/TB success experiences.

Abstract in French

Contexte :

Les Maladies Non Transmissibles et Traumatismes (MTNTs) représentent les principales causes de morbidité et de mortalité dans le monde, avec des projections d'une aggravation de la situation d'ici 2030, principalement dans les pays à revenu faible et intermédiaire. Les MTNTs deviennent un problème majeur de santé publique avec des implications sociales et économiques importantes en termes de besoins en soins de santé, de perte de productivité et de décès prématurés, et constituent donc un sérieux obstacle pour la réalisation des objectifs sociaux, sanitaires et économiques. Cette étude vise à établir l'impact des MTNTs au Kenya, leur corrélation avec les déterminants socio-économiques et la contribution de la pauvreté en tant que facteur de causalité et de résultat. Elle a également examiné l'état de préparation du système de santé, la disponibilité, l'efficacité et la couverture de l'approche actuelle et a recommandé un ensemble d'interventions pour arrêter et inverser le fardeau des MTNTs au Kenya dans le contexte de la Couverture Santé Universelle (CSU).

Méthodes :

L'impact des MTNTs a été déterminé à l'aide d'examens documentaires de la littérature publiée, d'estimations provenant de l'étude Global Burden of Disease et d'une analyse secondaire de l'enquête WHO STEP au Kenya sur les facteurs de risque des maladies non transmissibles (MNTs). L'étude GBD 2016 a été utilisée pour modéliser et estimer la prévalence, les années de vie ajustées sur l'incapacité (DALYs) et la proportion du total des décès dus aux MTNTs. L'enquête démographique et sanitaire du Kenya et le système de surveillance sanitaire et démographique (HDSS) ont été utilisés pour déterminer les causes de décès, les taux de mortalité globaux dus aux MTNTs et pour calculer un indice comparatif de statut socio-économique. Les données sur les dépenses nationales de santé ont été extraites des comptes nationaux de la santé du Kenya 2015/2016.

La disponibilité de base des services MTNTs a été estimée à l'aide de l'enquête 2013 sur la disponibilité des services et l'état de préparation au Kenya. Les conditions prioritaires ont été sélectionnées sur la base de l'impact global sur la santé, de la gravité en termes de mortalité prématurée, des handicaps causés, de la comparaison des inégalités causées et des priorités nationales dominantes. Un ensemble d'interventions rentables pour les pays à faible revenu pour permettre d'atteindre la CSU pour les MTNTs, a été tiré du groupe d'étude sur le contrôle des maladies et les priorités 3 (DCP3). Suite à une recommandation politique issue de ce travail en faveur de l'intégration des MTNTs dans les plateformes de soins primaires existantes telles que le VIH, la tuberculose et la santé maternelle, nous avons évalué la faisabilité de l'utilisation de la modélisation mathématique pour soutenir la prise de décision sur l'intégration des MTNTs et du VIH/SIDA.

Résultats :

Le Kenya est confronté à un lourd fardeau des MTNTs, qui représentent 37% de la charge de morbidité dans les DALYs au Kenya. Plus de la moitié (53 %) des DALYs de MNT et 72% des DALYs de traumatismes surviennent avant l'âge de 40 ans. De toutes les DALYs des MTNTs, 67 % étaient toutefois liées à des affections autres que les quatre MNTs mises en évidence dans le Plan d'Action Mondial de l'OMS sur les MNT. Les quintiles les plus pauvres ont connu un taux de mortalité due aux MTNTs considérablement élevé et avaient un accès limité aux services de diagnostic et de santé liés aux MTNTs.

Les MTNTs ont été associées à la réduction de 23,2% du revenu des ménages par rapport aux ménages touchés par les maladies transmissibles. Parmi les ménages souffrant de MNT, 29,9 % de ceux du quintile inférieur ont subi des dépenses catastrophiques (plus de 30 % du revenu total du ménage), contre 9,2 % dans le quintile de revenu le plus élevé. Les comtés ayant une proportion plus élevée de la population vivant dans le milliard le plus pauvre, avaient un nombre moyen faible de médicaments et de services de dépistage contre les MNTs ($r = -0,386$, $p = <0,01$). 14 conditions ont été recommandées, en s'appuyant sur le plan stratégique sur les MTNTs existant au Kenya, ainsi que sur un ensemble de trente-quatre interventions dans les domaines des soins ambulatoires, des soins hospitaliers, de la chirurgie, de la santé mentale, de la réadaptation et des soins palliatifs dans le contexte de la CSU pour un coût estimé à 520.146.154 USD ; ce qui représente un investissement supplémentaire de 11,97 USD par habitant par an et qui permettra d'éviter potentiellement 9.322 décès prématurés par an d'ici 2030.

Conclusions et perspectives :

Pour arrêter et inverser l'impact croissant des MTNTs au Kenya, les politiques doivent élargir leur attention au-delà des facteurs de risque comportementaux traditionnels des MNTs et adopter une approche plus globale avec des interventions inclusives tout au long de la vie, puisque des opportunités de prévention et de contrôle des MNTs existent dans toutes les cohortes du développement humain et pas seulement chez les personnes âgées.

Alors que les facteurs de risque comportementaux présentent un risque important attribuable aux MTNTs, la pauvreté joue un rôle indirect énorme à la fois dans la cause et les conséquences de ces maladies dans des contextes de ressources limitées comme le Kenya. Une approche gouvernementale globale est nécessaire puisque certains des déterminants des MTNTs, comme la pauvreté, échappent au contrôle direct du secteur de la santé. Comme les systèmes de lutte contre les MTNTs sont mal financés, l'intégration de certains éléments de leur prévention et de leur contrôle dans d'autres plateformes de soins primaires, comme le VIH, permettra de créer des synergies qui amélioreront l'accès et les résultats. Pour faciliter la prise de décision à grande échelle et considérant les éléments à intégrer, il est fortement recommandé de recourir à la modélisation mathématique en s'inspirant des expériences réussies avec le VIH/TB.

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CHAPTER 1: GENERAL INTRODUCTION

1.1 Background

Non-communicable diseases (NCDs) are illnesses usually of a chronic nature, with slow progression, a lengthy course and generally non-transmittable from one person to another (1). They are the leading causes of morbidity and mortality worldwide, with projections of even more burden by 2030 especially from low and middle income countries (2). According to the World Health Organization (WHO) estimates, NCDs kill approximately 41 million people worldwide annually, with the four major contributors of this burden being cardiovascular diseases, cancers, respiratory diseases and diabetes, accounting for around 71% of all NCD deaths globally (3).

Low and middle income countries (LMICs) constitute the biggest proportion of this disease burden, with almost three quarters of global NCD deaths, 82% of all NCD premature deaths (below age of 70 years) and having the highest number of healthy years lost/disability adjusted life years worldwide (4, 5). Almost 30 percent of NCD deaths in LMICs occur among people under age 60 years at the peak of their economic productivity compared to only 13 percent in high-income countries (6). It is projected that this imbalance of disease burden will continue tilting negatively in favor of low income settings such that by 2030 they will have eight times more deaths than the developed world (7). This is in line with the observation that NCDs currently receive minimal resource allocation from both governments and donor assistance relative to infectious disease in developing nations (8).

1.1.1 NCD and Injuries in the global and regional context

Between 1990 and 2017, the proportion of all disability adjusted live years attributable to NCDs raised from 19% to 30% of the total burden in the Sub Sahara region (9). On this trajectory, NCDs are set to overtake communicable, maternal, neonatal and nutritional conditions and diseases as the leading cause of mortality by 2030 (10).

While the burden of NCDs and Injuries is on a steep rise in LMICs, these countries' health systems are not resilient enough and are still grappling with a huge communicable diseases burden hence constituting the triple burden of disease (11, 12). These diseases, which themselves thrive in poverty and weak health systems, have a huge potential of retarding and crippling the economic development of the LMICs,

creating a vicious cycle of poverty and ill-health(11). The health effects of NCDs and related risk-factors are well established (13-16) and are a major public health concern with significant social and economic implications in terms of health care-needs, lost productivity and premature death and are thus a serious setback to the attainment of social, health and economic targets. According to the WHO Global status report on non-communicable diseases 2014, taking action on NCDs would save millions of lives and save LMIC's economies an estimated \$7 trillion in economic losses during 2011–2025 period of global action on NCDs (17).

Injuries resulting from traffic collisions, drowning, poisoning, falls or burns and violence from assault, self-inflicted violence or acts of war kill more than five million people worldwide annually and cause harm to millions more. While they account for 9% of global mortality, it is estimated that they contribute to dozens of hospitalizations, hundreds of emergency department visits and thousands of doctors' appointments. Equally, a large proportion of people surviving their injuries incurs temporary or permanent disabilities (18). Over 90% of injury deaths occurring in low- and middle-income countries where health-care systems are least prepared to meet the challenge. As such, injuries contribute to the vicious cycle of poverty owing to huge and catastrophic economic and social costs (19).

1.1.2 NCDs in the post 2015 developmental agenda

The growing prominence of NCDs and especially the resultant premature mortality and burden on the global economy has led to no less than 3 United Nations General Assembly High-level Meetings. The first meeting attracting Heads of State and Government and representatives was held on 20 September 2011 and culminated in a political declaration and commitment with a focus on developmental and social challenges and the economic impacts of NCDs, particularly for developing nations (20).

In 2014, the UN General Assembly (UNGA) having reviewed the patchy and uneven implementation of the 2011 political declaration produced an outcome document on NCDs that included four time-bound national commitments to be implemented in 2015 and 2016 to reduce risk factors of NCDs, provide better care for those with NCDs, and to keenly track trends and progress (21). On 27 September 2018, the United Nations General Assembly held the third High-level Meeting on the prevention and control of

non-communicable diseases, which undertook a comprehensive review of the global and national progress achieved in putting measures in place to protect people from premature mortality from cardiovascular diseases, chronic lung diseases, cancers and diabetes (22).

In the wake of the UN high level meetings and in response to the growing NCDs crisis, the WHO developed a Global Monitoring Framework for NCDs with nine voluntary targets to reduce mortality due to NCDs by 25% by 2025 (23). This framework is key to monitor and survey the implementation of the interventions of the Global Action Plan for the Prevention and Control of NCDs 2013–2020 that was adopted by member states in by the Sixty-fifth World Health Assembly in resolution WHA65.8 (24). Further, as part of the post 2015 developmental agenda, Sustainable Development Goal (SDG) target 3.4 was set to among other things reduce premature mortality from non-communicable diseases (NCDs) by a third by 2030 relative to 2015 levels, and to promote mental health and wellbeing all in the context of a Universal Health Coverage (UHC) (25).

1.1.3 Kenyan situation; Growing burden of NCDs

With a gross national income (GNI) of 1,460, Kenya is a lower-middle-income economy (26). While the country has registered a steady economic growth averaging 5.7%, poverty is still a major hinderance to economic growth and impacts negatively on health outcomes (27). The world Bank estimates that the proportion of Kenyans living on less than the international poverty line (US\$1.90 per day in 2011 PPP) has declined from 43.6% in 2005/06 to 35.6% in 2015/16 (28). According to the WHO disease burden and mortality estimates, the proportion of all deaths in the WHO Africa region that are attributable to NCDs increased from 22.8% (2.2 million) in the year 2000 to 34.2% (3.0 million) in the year 2016 with Kenya registering 27% of all deaths as attributable to NCDs (29).

Despite Kenya being considered as “ready and compliant” as per the 4 commitments of the 2014 UN Outcome Document on NCDs (Countries that have set national targets for NCDs By 2015, Countries with national NCD multi-sectoral policies and plans By 2016, Countries implementing the best buys to reduce risk factors for NCDs By 2016 and countries implementing best buys to enable health systems to respond) (21), a

deeper look at the systems readiness and service availability to provide NCD specific interventions to halt and reverse the burden of NCDs was found wanting (30). In line with the prevailing health policy, the Kenyan Ministry of Health launched the Kenya National strategy for the prevention and control of NCD 2015 to 2020, to guide the implementation of specific measures to address the NCD burden (31). Although in this strategy Kenya adopted the global vision of halting and reversing the global NCD threat, the country's capacity to do so especially in the context of the SDGs is doubtful (32) owing to the low prioritization and budgetary allocation for the same.

This work aimed at establishing the burden of disease from NCDs and Injuries in Kenya, their relation to socioeconomic determinants and the contribution of poverty as a driver of the NCD and Injuries burden. It further looked at system readiness, availability and coverage of NCD and injuries services in the Kenyan health sector and the effectiveness of the current approach towards halting and reversing the NCD burden in Kenya in the context of UHC. Once completed, it proposed potential interventions and innovations to be introduced, scaled and or intensified within the health sector to target the priority NCDI conditions.

1.1.4 Looking at NCDIs beyond the behaviorally mediated models

The global focus of the prevention and control of NCDs has been on four major diseases and their four shared risk factors as endorsed by the World Health Organization (WHO) in the Global Action Plan for the Prevention and Control of Noncommunicable diseases in 2013 (24). The major emphasis on tobacco control, alcohol control, physical activity, and healthy diet as well as hypertension, diabetes, asthma, and cancer (primarily lung cancer) was put forward as a global agenda to consolidate focus on behavioral and lifestyle-associated risk factors and disease conditions and to halt and reverse the global burden of NCDs by starting with the diseases contributing the biggest burden (24). This focus has since been expanded during the 2018 UN high level meeting to a five by five matrix including mental health and environmental risk factors represented by air pollution (22, 33).

While this five by five framework has provided valuable guidance to strategic planning and activities for the prevention of control of non-communicable diseases and injuries (NCDIs) in countries where these conditions form a considerable share of national

morbidity and mortality such as Kenya (34), this framework only represents NCDs that are primarily behaviorally mediated amongst ageing and urbanizing populations.

From as early as 2011, the Program on Global NCDs and Social Change in the Harvard Medical School Department of Global Health and Social Medicine, put forward the idea that the NCDs afflicting the poorest populations were more likely to be the result of infections and harmful environments than behavioural risk factors (35). The broadened view incorporates NCDs like type 1 and malnutrition-associated diabetes, rheumatic heart disease, Burkitt's lymphoma, cervical cancer, haemoglobinopathies, kidney diseases, epilepsy, depression, appendicitis, and trauma in its various manifestations.

Despite none of these “small” NCDs alone representing a major cause of death or disability, collectively, however, they could account for more than a third of the disease burden among those living in extreme poverty, with more than two-thirds of this burden concentrated among individuals younger than 40 years (36, 37). The distinctive epidemiology of NCDs among the poorest people highlights the limitations of the common five by five behavioural risk factor model, (22) and underlines the need to emphasis both approaches on the role of material poverty and on integrated health-service interventions to address the revised range of diseases (38).

The control of NCD requires careful consideration of the underlying factors and calls for a holistic view of health and institutionalization of preventive and control measures using a bio-psycho-social model (32). Within the SDG context and in the spirit of leaving no one behind, there is a need to re-look at the NCD “pandemic” in the country using a multisectoral approach considering the inputs of causation such as commercial determinants like trade and psychosocial determinants like poverty that are domiciled outside the health sector and in the direct control of other sectors of government (39).

1.1.5 The Kenya NCDI Poverty Commission and its mandate

While one of the overarching intentions of the UHC rollout was to shield citizens from the catastrophic cost incurred from seeking health care, there was minimal evidence on the contribution of different diseases groupings towards impoverishing households in their quest for health. There was also concern that the Kenyan health system had been and largely remains optimised for infectious diseases from a traditional perspective

owing to the heavy burden of communicable diseases like HIV, TB Malaria and other tropical conditions and may not be fit for purpose for the emerging NCDI burden.

The Kenya Ministry of Health launched the Kenya NCDI Poverty Commission to assist in recommending a package of cost-effective health sector interventions that could be implemented in Kenya within the UHC rollout that would halt and reverse the NCDI burden in a more sustainable and cost-effective way cognisant of the dire resources constrain.

Towards generating a priority list of NCDIs, a prioritization exercise was carried out with an emphasis based on the overall health impact of each condition (“burden of disease”), the severity of the condition in terms of premature mortality (“severity”), the extent of disability caused by the condition on each individual affected (“disability”), the inequity of health outcomes from the condition as compared to other regions of the world (“equity”) and national diseases/conditions priorities (30). The commissions study group developed a local investment case with pro-poor policies and integrated health service delivery platforms to achieve substantial reductions in premature death, suffering, and poverty due to NCDs and injuries.

1.1.6 Sources of data

The analysis relied on the findings of the global Lancet Commission on Reframing Non-Communicable Diseases and Injuries for the Poorest Billion which suggested that a large proportion of the DALYs due to NCDIs may be due to risk factors and conditions other than those represented in the behavioral five by five model framework (30, 39). This differential burden of NCDs and risk factors may be particularly pronounced in younger populations and those living in extreme poverty, as is present in a large proportion of the Kenyan population (30). A similar pattern was observed when individual-level population-based data from 44 LMICs that had conducted the WHO Stepwise Approach to Surveillance (STEPS) survey from 2005 was pooled and analyzed.

The WHO STEPwise approach to NCD risk factor surveillance (STEPS) survey was carried out in Kenya for the first time in 2015, with collection of data on behavioral risk factors, medical history, physical measurements and biochemical tests. The secondary analysis focused on the relationship between age, gender, residence and socio-economic strata and the prevalence of various NCDs and their risk factors (40).

Modelling was done with additional data sources that include the Kenya Demographic and Health Survey (DHS), Kenya Medical Research Institute (KEMRI)/Centers for Disease Control and Prevention (CDC) Health and Demographic Surveillance System (HDSS) in rural Siaya County in western Kenya and the Nairobi Urban HDSS in two urban slum communities in Nairobi. The IHME GBD 2016 data was utilized to model and estimate prevalence, disability-adjusted life years (DALYs), and percent of total deaths for specific NCDs, injuries, and risk factors (41). The NCDI burden distribution was further analysed by age, causes of death and overall death rates across socioeconomic status.

To comprehend the preparedness and readiness of the health system to tackle the NCD burden, the most recent Kenya Service Availability and Readiness Assessment (SARA) conducted in 2013 was reviewed. This was mostly to evaluate how the health care systems was optimized to tackle non communicable diseases especially at the primary care level. In Kenya, Primary Health Care (PHC) is the first level of contact between the individual and the health system where essential healthcare is provided and forms the basis for the other levels of health care services (42).

1.1.7 Filling the data gap; The role of mathematical models in informing integration of NCDs into primary care platforms.

As part of innovative solutions suggested by the commission towards halting and reversing the burden of NCDs in the context of diminished resources, integrating services for non-communicable diseases into existing primary care platforms such as HIV programs was recommended as a way of strengthening health systems, reducing redundancies and leverage existing systems to rapidly scale-up underdeveloped programs like the NCD program in Kenya (43). NCD service integration is a viable option to tap into the redundant edge of funded primary care platforms like HIV, TB, Maternal health, child health and Community health and to invest in the synergies and lessons thereof. In finding an entry point into integrating NCDs into other programs, the third paper of this work looks at the potential of utilizing mathematical modelling to support decision-making on integration of non-communicable diseases into HIV care considering the paucity of quality NCD data for policy making and review (44). Mathematical modelling provides a powerful tool to address questions around

priorities, optimization, scaling and implementation of such programs to ensure that synergies are harnessed and right mix of interventions are chosen to avoid losing gains made by the stronger program as you integrate (45).

Service integration especially at the primary health care level has been shown to generate advantages for both provider and user, and has been demonstrated to be cost-effective, practical and rapidly scalable (46-48). Policymakers in Malawi, Kenya, South Africa and Swaziland, countries have considered integration of NCD and HIV care but a lack of robust evidence and policy framework hampers largescale implementation of HIV/NCD integration (43). Considering this paucity of quality data for policy and planning of NCD services, it was argued that mathematical modelling has a role in exploring health system capacity needs, support implementation of integration and inform policy decisions on integrated care for multi-morbidity and optimizing healthcare provision for NCDs in Kenya (44).

While the knowledge base, expertise and routine use of mathematical modelling to close the policy data gap is a relatively new phenomenon in the Kenyan health policy terrain, the successful use of modelling to inform policy and decision making will depend on several factors including policy makers' comfort with and understanding of models and their uncertainties, modelers understanding of the policy makers questions, funding opportunities and building local modelling capacity to ensure sustainability (45).

1.2 Objectives

This work is a compilation of 3 publications in which I am the primary author and 9 in which I am part of the authorship and in which I am listed in my affiliation to the University of Geneva's Faculty of Medicine.

The objectives of this work were to

- a. Establish the burden of disease of NCDs and Injuries in Kenya, particularly in relation to socioeconomic determinants and the contribution of poverty as a driver of the NCD and Injuries burden.
- b. Understand the Health system readiness, availability and coverage of NCD and injuries services in the Kenyan health sector and the effectiveness of the current capacity in halting and reversing the NCD burden in Kenya in the context of UHC.
- c. Propose and prioritize from among NCDs and injuries potential interventions to be introduced, scaled and/or intensified within the health sector to target these priority NCDI conditions.
- d. Estimate and model the cost and potential impact of investing in these interventions and innovations like service integration.

As an adjunct to individual countries STEPS data, I participated in my affiliation in a large multi country study that collated the WHO STEPS datasets from 55 Low - and Middle-Income Countries to produce a huge database of whose findings have also influenced the opinions, conclusions and recommendations of this thesis.

The thrust of the work was to redefine how we look at NCD programming and policy using poverty lenses and come up with pro-poor or social economically sensitive interventions and suggestions for the government to implement in a multisectoral approach to halt and reverse the burden of NCDs within the UHC framework

CHAPTER 2: METHODOLOGICAL CONTRIBUTION

This thesis comprises three main publications with the candidate as the first author and my supervisors as co-author as well as several related supplemental publications conducted within my learning period in the PhD program and in which I am listed as a co-author in my affiliation to the university of Geneva's faculty of medicine.

2.1 Scientific articles in peer reviewed journals in with the candidate is the first author and my supervisors are co-author

Article 1:

Mwangi, K., Gathecha, G., Nyamongo, M., Kimaiyo, S., Kamano, J., Bukachi, F., Odhiambo, F., Meme, H., Abubakar, H., Mwangi, N., Nato, J., Oti, S., Kyobutungi, C., Wamukoya, M., Mohamed, S.F., Wanyonyi, E., Ali, Z., Nyanjau, L., Nganga, A., Kiptui, D., Karagu, A., Nyangasi, M., Mwenda, V., Mwangi, M., Mulaki, A., Mwai, D., Waweru, P., Anyona, M., Masibo, P., Beran, D., Guessous, I., Coates, M., Bukhman, G. and Gupta, N., 2021. **Reframing Non-Communicable Diseases and Injuries for Equity in the Era of Universal Health Coverage: Findings and Recommendations from the Kenya NCDI Poverty Commission.** *Annals of Global Health*, 87(1), p.3. DOI: <http://doi.org/10.5334/aogh.3085>

For the first publication, as the chair of the Kenyan NCD and Injuries Poverty Commission, I was involved in conceptualizing the commission, its mandate and work and eventually in presenting the findings to the government for endorsement and policy utility. I also participated in the protocol elaboration, literature search, data collection, analysis, paper writing the eventual publication of the research findings in the annals of Global Health.

Within this publication, mixed methods with 4 main sources of data were utilized. The Kenya STEP Survey 2015 was reviewed to assess behavioural and metabolic risk factors for NCDs (49). Data from this survey was secondarily analysed to obtain wealth quintile disaggregation for survey questions pertaining to diagnosis and treatment for hypertension and diabetes. Availability of referral level services was provided by experts' report from the members of the Commission.

Data from the Kenya Demographic and Health Survey (DHS) were used to gather nationally representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition (50). This survey also contained data on tobacco use, alcohol use, and adult

nutritional status among men and women aged 15–49 years disaggregated by wealth quintile.

Data from the Kenya Medical Research Institute (KEMRI)/Centers for Disease Control and Prevention (CDC) Health and Demographic Surveillance System (HDSS) in rural Siaya County in western Kenya and the Nairobi Urban HDSS in two urban slum communities in Nairobi were analysed to determine cause of death and overall death rates due to NCDs and calculate comparative distribution of NCDs by socioeconomic status. Equally, the GBD 2016 study was utilized to model and estimate prevalence, disability-adjusted life years (DALYs), and percent of total deaths for specific NCDs, injuries, and risk factors ([41](#)). The burden distribution was further analysed by age and year.

The population in each county living with at least four levels deprivations from an adapted Multidimensional Poverty Index (MPI) were used to construct an index of socioeconomic indicators from the Kenya DHS, including schooling, school attendance, electricity, sanitation, water, flooring, cooking fuel, and household assets ([51](#)).

Baseline availability of services and readiness of the system for NCD prevention and control was estimated using the 2013 Kenya Service Availability and Readiness Assessment (SARA) ([52](#)). Availability of services was analysed by disease condition, level of the health system, rural or urban location, and county. Both reported availability of services and readiness by the observed availability of designated tracer items were analysed. The association of the percentage of health facilities with service/medication availability or readiness with proportion of households living in poverty per the MPI across counties was tested using Pearson's correlation coefficient and the p-value of the slope from a simple least squares regression. Essential medications for NCDs were obtained from the Kenya Essential Medications List 2016 ([53](#)).

Data regarding national health expenditures were extracted from the Kenya National Health Accounts 2015/2016 ([54](#)). These data were reviewed and validated by commissioners to establish baseline availability and financing of services.

A process was undertaken to prioritize among NCDs conditions for the Kenya health sector based on principles of priority setting established by the WHO Consultative Group on Equity and Universal Health Coverage (UHC) ([55](#)). The commission study

group analyzed and ranked NCDI conditions based on the estimated burden of disease of each condition in Kenya as measured by DALYs in the GBD 2016 (41). The severity of each condition was measured using the average years of life lost (YLL) per death, and the disability of each condition was measured using the years of life with disability (YLDs) per incident case. The impact in Kenya compared to high-income countries was estimated for each condition by comparing the rate of DALYs per 100,000 population. A total of 190 NCDI conditions from the GBD database were analyzed by these metrics, and a summary score was provided to each condition according to the average of the ranking quartiles on each metric.

Fifty conditions with the highest summary score were then reviewed by the study group and 14 conditions selected for policy attention based on: 1) their ability to contribute significantly to adverse health and economic consequences in Kenya, 2) how feasible and effectively they can be controlled in Kenya, and 3) their being complementary to ongoing strategy and efforts by the Government of Kenya (GoK) as per the national health policy and NCD strategic plan (31, 56).

Alongside the 14 focus conditions, the study group recommended a package of thirty-four interventions to be introduced or intensified within the health sector. These interventions were selected on the criteria of potential health impact, cost-effectiveness, financial risk protection, and priority to the “worst-off”, including those that could avert more severe or premature complications.

Information regarding priority setting established by the WHO Consultative Group on Equity and Universal Health Coverage (DCP3) (57). The unit cost for each intervention was provided on average across low-income countries, which is described in greater detail elsewhere [33]. These interventions were reviewed by the study group for 1) alignment with stated NCDI priority conditions, and 2) feasibility and desirability in the Kenya context. Each intervention was assigned a baseline coverage in Kenya, estimated from existing data sources as well as expert experience from the commission and confirmation from the Ministry of Health. With consultation from national and regional health managers, the Commission then assigned a feasible target coverage for each intervention by the year 2030. The total cost of implementing these interventions and premature deaths averted was then calculated.

Article 2:

Mwangi KJ, Mwenda V, Gathecha G, Beran D, Guessous I, Ombiro O, Ndegwa Z, Masibo P. **Socio-economic and demographic determinants of non-communicable diseases in Kenya: a secondary analysis of the Kenya stepwise survey.** Pan Afr Med J. 2020 Dec 16;37:351. doi: 10.11604/pamj.2020.37.351.21167 PMID: 33796165; PMCID: PMC7992900

In the second publication, as the principal investigator of the Kenyan STEPwise approach to NCD risk factor surveillance (STEPS) survey, I participated in the protocol development, literature search, questionnaire design, training of enumerators, revision of the sampling frame, data collection, analysis and participated in writing of publications.

As the Principal investigator I was also co-author of other supplementary publications emanating from this work. In this particular publication a further analysis of the STEPS dataset was conducted to evaluate the socio-economic and demographic determinants of non-communicable diseases in Kenya as published in the Pan African Medical Journal.

The Kenyan STEPwise approach to NCD risk factor surveillance (STEPS) survey is a standardized WHO survey designed to enable countries collect core data on major risk factors that drive the NCD burden. It is designed with a flexible structure to allow different countries to adapt it to their individual situations [16]. It involves three steps: a questionnaire-based assessment of socio-economic, nutritional and behavioural information; step two involves simple physical measurements and step three involves biochemical measurements of blood sugar and cholesterol.

The Kenyan STEPwise approach to NCD risk factor surveillance (STEPS) survey 2015 was conducted as a cross-sectional household survey targeting adults between the ages of 18 to 69 years. The STEPS survey was carried out from April to June 2015. Its focus was the four main behavioural risk factors of NCDs (tobacco use, harmful use of alcohol, unhealthy diets and physical inactivity), the four key biological risk factors for NCDs (overweight and obesity, raised blood pressure, raised blood lipids and raised blood glucose) as well as burden of unintentional injuries and oral health.

In this publication, a secondary analysis of the STEPS 2015 data was performed. A full description of the survey methods is available elsewhere (49). The outcome variables for this study included prevalence of hypertension, heavy episodic drinking, smoking,

central obesity, non-use of seatbelts while driving in a vehicle or not wearing helmets while riding a bicycle or motorcycle. The outcome variables were correlated across the various independent variables used in this study including sex, age, marital status, level of education, occupation, residence and socio-economic status (wealth band).

Logistic regression analyses were used to compute adjusted odds ratios (aOR) for each exposure variable while controlling for all the other variables (confounders) in the model. Estimates that adjust for the complex, multi-level sampling design, were created including stratifying by Kenyan regions and enumeration areas. Adjusted odds ratios were calculated for each exposure variable while controlling for all the other variables in the model with 95% confidence intervals that excluded the null (aOR equal to 1.0) considered statistically significant. This secondary analysis included 4484 respondents after omitting records that had missing values for the independent and dependent variables from the initial survey sample size of 4500 respondents.

Article 3:

Kibachio, J., Mwenda, V., Ombiro, O., Kamano, J. H., Perez-Guzman, P. N., Mutai, K. K., Guessous, I., Beran, D., Kasaie, P., Weir, B., Beecroft, B., Kilonzo, N., Kupfer, L., & Smit, M. (2020). **Recommendations for the use of mathematical modelling to support decision-making on integration of non-communicable diseases into HIV care.** Journal of the International AIDS Society, 23 Suppl 1(Suppl 1), e25505.

<https://doi.org/10.1002/jia2.25505>

This publication was a part of a special issue in the Journal of the International AIDS Society on Integrating services for HIV and related comorbidities and the role mathematical modelling to inform policy and practice.

This work provided recommendations for the use of mathematical modelling to support decision-making on integration of non-communicable diseases into HIV care and was also part of a compendium from this journal issue presented at the 2020 Virtual 23rd International AIDS Conference.

This publication was developed after a policy recommendation from the work of the Kenyan NCD and Injuries Poverty Commission that integration of NCD services for non-communicable diseases (NCDs) into existing primary care platforms such as HIV programmes is a possible avenue of strengthening health systems, reducing

redundancies, and leveraging existing primary care health systems to rapidly scale-up underdeveloped programmes.

Given the paucity of quality NCD data for planning and policy, mathematical modelling was theorized to provide a powerful tool to address questions around setting priorities, optimization, and implementation of such programmes.

In this publication, the place of NCD-HIV integration was evaluated using Kenya as a case-study to highlight how mathematical modelling has supported wider policy formulation and decision-making in healthcare and to collate stakeholders' recommendations on use of models for NCD-HIV integration in decision making.

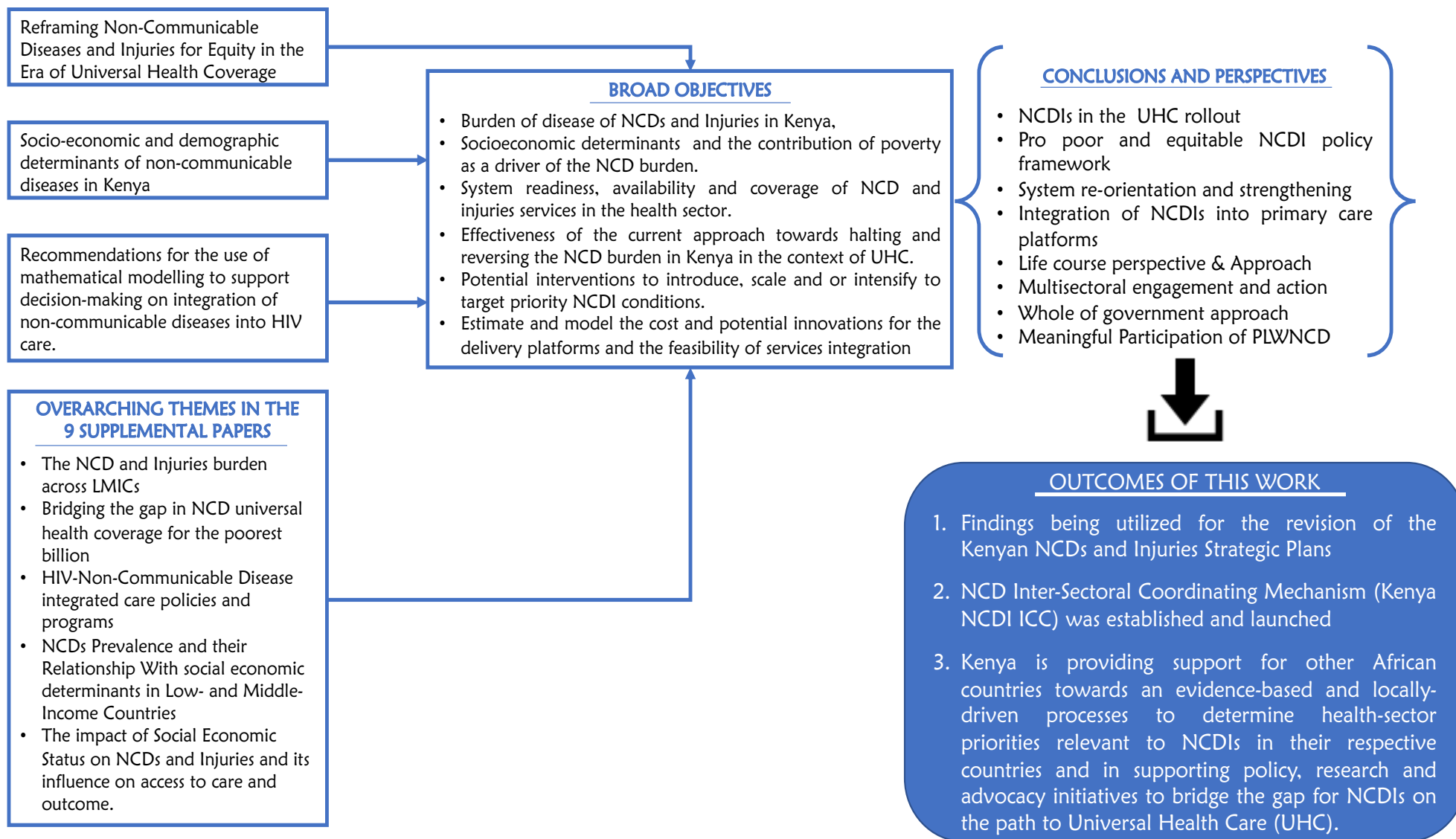
At the point of collating key informant opinions, convenient targeted sampling was utilized followed by snowballing for potential opinion leaders and experts. This work further developed towards mapping the Current and future Noncommunicable Disease Burden in Kenya by Human Immunodeficiency Virus Status - a modelling Study that aimed to quantify current and future NCD burden in Kenya by human immunodeficiency virus (HIV) status.

2.2 Supplementary articles related to the thesis in which the candidate is an author and affiliated to the institute of Global Health; Faculty of Medicine, University of Geneva.

Within the supplementary articles that mostly relied on pooled individual-level population-based data from 44 LMICs or cross-sectional nationally representative household surveys I participated in the conceptualization, collation and review of Kenyan data and supported the contextualization and review of the published manuscript

For the publication "The Lancet NCDI Poverty Commission: bridging a gap in universal health coverage for the poorest billion. Lancet. 2020;396(10256):991-1044. pmcid: [pmc7489932](https://pubmed.ncbi.nlm.nih.gov/37489932/) doi: [10.1016/s0140-6736\(20\)31907-3](https://doi.org/10.1016/s0140-6736(20)31907-3), I was part of the publication as The Lancet NCDI Poverty Commission study group that includes the co-chairs and coordinators of the first 11 countries to initiate National NCDI Poverty Commissions, Groups and Consortia representing Kenya.

2.3 Conceptual framework



Reframing Non-Communicable Diseases and Injuries for Equity in the Era of Universal Health Coverage: Findings and Recommendations from the Kenya NCDI Poverty Commission



Annals of
Global Health

ORIGINAL RESEARCH

KIBACHIO MWANGI
GLADWELL GATHECHA
MARY NYAMONGO
SYLVESTER KIMAIYO
JEMIMA KAMANO
FREDRICK BUKACHI
FRANK ODHIAMBO
HELLEN MEME
HUSSEIN ABUBAKAR
NELSON MWANGI
JOYCE NATO
SAMUEL OTI

CATHERINE KYOBUTUNGI
MARYLENE WAMUKOYA
SHUKRI F. MOHAMED
EMMA WANYONYI
ZIPPORAH ALI
LOISE NYANJAU
ANN NGANGA
DORCAS KIPTUI
ALFRED KARAGU
MARY NYANGASI
VALERIAN MWENDA
MARTIN MWANGI

AARON MULAKI
DANIEL MWAI
PAUL WAWERU
MAMKA ANYONA
PENINAH MASIBO
DAVID BERAN
IDRIS GUESSOUS
MATT COATES
GENE BUKHMAN
NEIL GUPTA

*Author affiliations can be found in the back matter of this article

]u[ubiquity press

CORRESPONDING AUTHOR:
Dr. Kibachio Mwangi

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Institute of Global Health, Faculty of Medicine, University of Geneva, Geneva, Switzerland
World Health Organization (WHO) South Africa Country Office, South Africa

kibachiojoseph@gmail.com

ABSTRACT

Background: Kenya has implemented a robust response to non-communicable diseases and injuries (NCDIs); however, key gaps in health services for NCDIs still exist in the attainment of Universal Health Coverage (UHC). The Kenya Non-Communicable Diseases and Injury (NCDI) Poverty Commission was established to estimate the burden of NCDIs, determine the availability and coverage of health services, prioritize an expanded set of NCDI conditions, and propose cost-effective and equity-promoting interventions to avert the health and economic consequences of NCDIs in Kenya.

Methods: Burden of NCDIs in Kenya was determined using desk review of published literature, estimates from the Global Burden of Disease Study, and secondary analysis of local health surveillance data. Secondary analysis of nationally representative surveys was conducted to estimate current availability and coverage of services by socioeconomic status. The Commission then conducted a structured priority setting process to determine priority NCDI conditions and health sector interventions based on published evidence.

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Findings: There is a large and diverse burden of NCDs in Kenya, with the majority of disability-adjusted life-years occurring before age of 40. The poorest wealth quintiles experience a substantially higher deaths rate from NCDs, lower coverage of diagnosis and treatment for NCDs, and lower availability of NCDI-related health services. The Commission prioritized 14 NCDs and selected 34 accompanying interventions for recommendation to achieve UHC. These interventions were estimated to cost \$11.76 USD per capita annually, which represents 15% of current total health expenditure. This investment could potentially avert 9,322 premature deaths per year by 2030.

Conclusions and Recommendations: An expanded set of priority NCDI conditions and health sector interventions are required in Kenya to achieve UHC, particularly for disadvantaged socioeconomic groups. We provided recommendations for integration of services within existing health services platforms and financing mechanisms and coordination of whole-of-government approaches for the prevention and treatment of NCDs.

INTRODUCTION

The focus of the prevention and control of non-communicable diseases (NCDs) has been on four major diseases and four risk factors, as framed by the World Health Organization (WHO) in the Global Action Plan (GAP) for the Prevention and Control of Non-communicable Diseases in 2013 [1]. The emphasis on tobacco control, alcohol control, physical activity, and healthy diet as well as cardiovascular diseases, cancer, chronic obstructive pulmonary disease, and cancers was put forward as a global agenda to consolidate focus on the complex interplay between the socio-economic, environmental and modifiable behavioral factors that underlie the causation and distribution of these chronic conditions.

While this four by four framework has provided valuable guidance to strategic planning and activities for the prevention of control of non-communicable diseases and injuries (NCDIs) in countries such as Kenya, where these conditions form a considerable share of national morbidity and mortality [2], it was recently expanded during the 2018 UN high level meeting to a five by five that now includes air pollution and mental health.

However, recent studies have suggested that a large proportion of the global DALYs due to NCDs may be due to risk factors and conditions other than those represented in this framework [3]. This differential burden of NCDs and risk factors may be particularly pronounced in younger populations and those living in extreme poverty, as is present in a large proportion of the Kenyan population. Although data from primary studies is limited, a higher prevalence has been shown in urban and wealthier demographic groups in Kenya for several common and lifestyle-associated NCDs, such as hypertension [4], diabetes [5–7], and chronic respiratory diseases [8, 9], as compared to more rural populations and lower socioeconomic groups. Meanwhile, the prevalence may be higher for several severe and highly disabling NCDI conditions, such as esophageal cancer [10], epilepsy [11], mental disorders [12], suicide [13], violent injuries [14, 15], intimate partner violence [16, 17], falls [18], animal bites [18], and burns [18, 19].

The economic impact of NCDs in Kenya is more impoverishing than communicable diseases and is more pronounced in the poor [20]. For households reporting NCDs in a nationally-representative household survey, 29.9% of those in the lowest quintile experienced catastrophic expenditures (defined as >30% of total household income), compared to 9.2% in the highest income quintile [21]. The rate of catastrophic expenditure was also higher for rural (20.8%) as compared to urban (13.6%) households.

It is in this context that the Kenya NCDI Poverty Commission (herein “Commission”) was established and launched by the Kenya Ministry of Health in December 2017, in collaboration with the Lancet Commission on Reframing Non-Communicable Diseases and Injuries for the Poorest Billion. The

Commission was comprised of representatives from the Ministry of Health (MOH), academic institutions, WHO, World Bank, research institutions, civil society, not-for-profit organizations, and other key cross-sectoral stakeholders in NCD control. The intent of this Commission was to use existing data sources to best summarize the impact of NCDIs on the health of Kenyans, establish the relationship of poverty with NCDIs in Kenya, develop a proposed package of health sector interventions to raise the visibility and understanding of this problem among policy makers and civil society in Kenya, and inform future planning and resource allocation. We here present the key findings and recommendations from the Kenya NCDI Poverty Commission (full report available at: <http://www.ncdipoverty.org/kenya-report>) [22].

METHODS

A literature review on NCDIs was conducted, consisting of all studies published from 2006–2016 (extended to January 31st, 2017). The search terms corresponded to the Global Burden of Disease (GBD) “level 2 NCDI” categories combined with the word “Kenya” [23]. Studies were included if they met any of the following criteria: (1) contained data on prevalence, risk or mortality from NCDIs preferably stratified by socioeconomic strata or by geographic location; (2) reported distributions of types of NCDI cases among admissions and deaths at health facilities; and (3) reported on interventions or service delivery models for NCDIs.

The GBD 2016 study was utilized to model and estimate prevalence, disability-adjusted life years (DALYs), and percent of total deaths for specific NCDs, injuries, and risk factors [23]. The burden distribution was further analyzed by age and year. Data from the Kenya Demographic and Health Survey (DHS) were used to gather nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition [18]. This survey also contained data on tobacco use, alcohol use, and adult nutritional status among men and women aged 15–49 years disaggregated by wealth quintile. Data from the Kenya Medical Research Institute (KEMRI)/Centers for Disease Control and Prevention (CDC) Health and Demographic Surveillance System (HDSS) in rural Siaya County in western Kenya and the Nairobi Urban HDSS in two urban slum communities in Nairobi were analyzed to determine cause of death and overall death rates due to NCDIs and calculate comparative distribution of NCDIs by socioeconomic status [15, 24].

The population in each county living with at least four levels deprivations from an adapted Multidimensional Poverty Index (MPI) were used to construct an index of socioeconomic indicators from the Kenya DHS, including schooling, school attendance, electricity, sanitation, water, flooring, cooking fuel, and household assets [25].

Baseline availability of services was estimated using the 2013 Kenya Service Availability and Readiness Assessment (SARA) [26]. Availability of services was analyzed by disease condition, level of the health system, rural or urban location, and county. Both reported availability of services and readiness by the observed availability of designated tracer items were analyzed. The association of the percentage of health facilities with service/medication availability or readiness with proportion of households living in poverty per the MPI across counties was tested using Pearson’s correlation coefficient and the p-value of the slope from a simple least squares regression. Essential medications for NCDIs were obtained from the Kenya Essential Medications List 2016 [27]. The Kenya STEP Survey 2015 was reviewed to assess behavioral and metabolic risk factors for NCDs [14]. Data from this survey was secondarily analyzed to obtain wealth quintile disaggregation for survey questions pertaining to diagnosis and treatment for hypertension and diabetes. Availability of referral level services was provided by experts’ report from the members of the Commission.

Data regarding national health expenditures were extracted from the Kenya National Health Accounts 2015/2016 [28]. These data were reviewed and validated by commissioners to establish baseline availability and financing of services.

KEY FINDINGS

OVERALL BURDEN OF NCDIS IN KENYA

Overall, NCDIs accounted for 37% of the disease burden in DALYs in Kenya with more than half (53%) of NCD DALYs and 72% of injury DALYs occurring before the age of 40 (Figure 1). Of all DALYs from NCDs, 67% were related to conditions other than the four NCDs highlighted in the WHO GAP (Figure 2). This is notably higher than in high-income countries, where only 53% of NCD DALYs are due to conditions other than these four disease areas [23]. NCD disease categories with the highest proportion of DALYs occurring under the age of 40 included mental health disorders (74%), neurological disorders (70%), and chronic respiratory diseases (50%). NCDIs were responsible for 35% of all deaths in Kenya, and 22% of these occurred before the age of 40.

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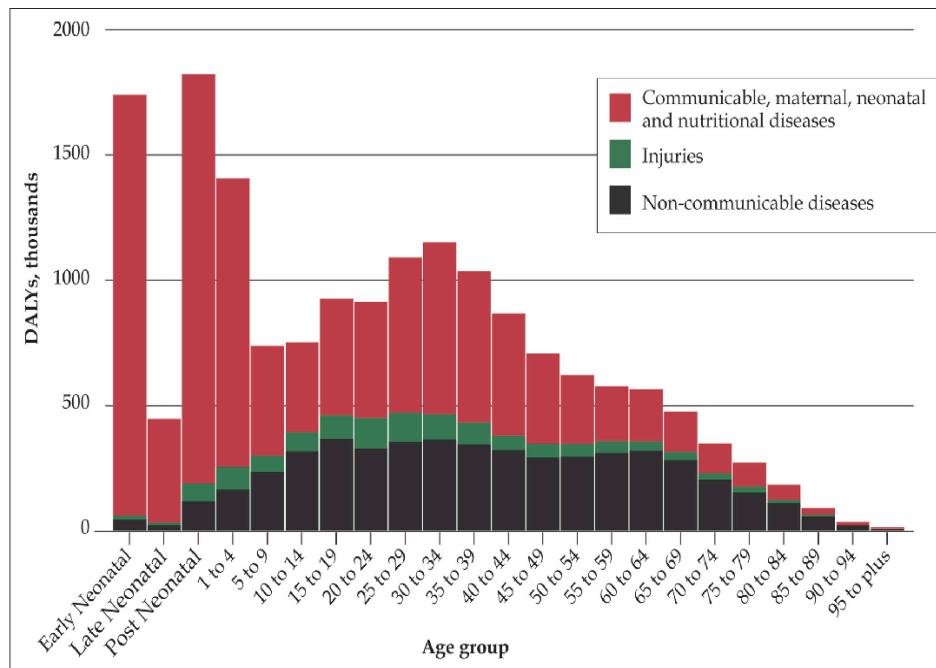


Figure 1 Disability-adjusted life years due to major disease groups, by age (GBD 2016).

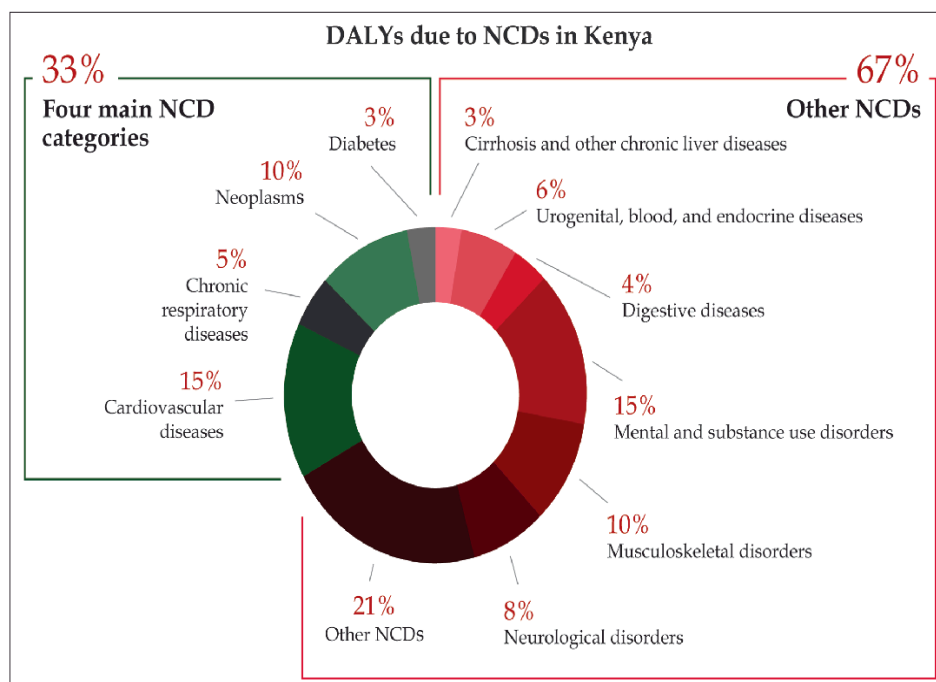


Figure 2 DALYs from NCDs in Kenya due to the four NCDs included and not included in the Global Action Plan (GBD 2016).

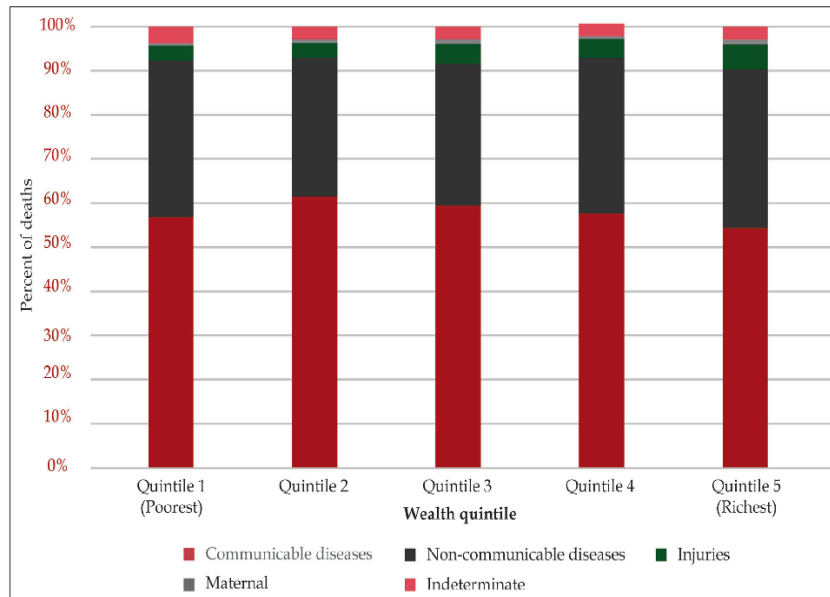
BURDEN OF NCDIS IN RELATION TO SOCIOECONOMIC STATUS

Data from the KEMRI/CDC HDSS in Siaya County, a primarily rural catchment area located in the western region of the country from 2003–2016, reported 36.1% of deaths were attributed to NCDs and 4.6% were attributed to injuries by verbal autopsy methods. Individuals in the lowest wealth quintile had a comparable proportion of deaths due to NCDIs (39.0%) as compared to the highest wealth quintile (41.6%) ([Figure 3a](#)). The leading causes of NCD deaths among the poorest quintile were cancers (32.1%), cardiovascular disease (26.3%), and abdominal causes (16.2%). Using the multidimensional poverty index to assess poverty, 39.5% of Kenyans would be considered as living in the poorest billion people globally.

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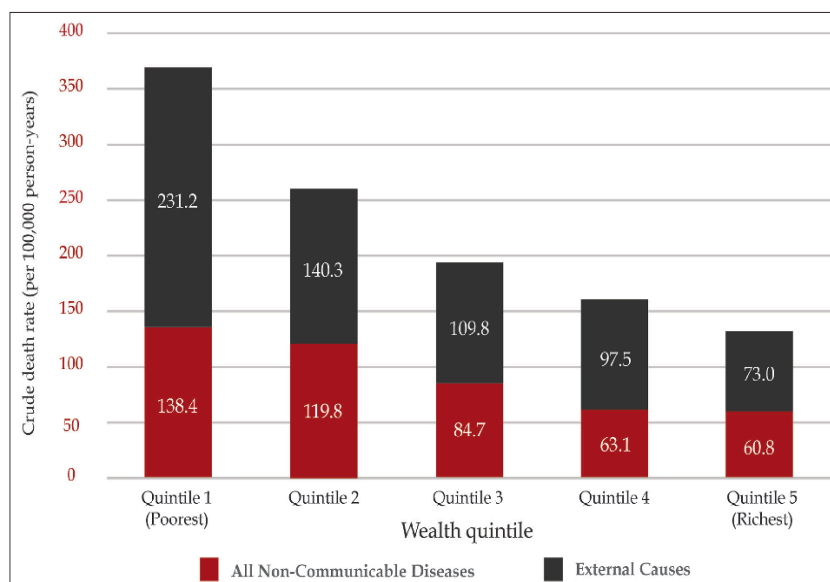
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[Figure 3a](#) Proportion of cause of death by wealth quintile in KEMRI/CDC HDSS in Siaya County 2003–2016 (source: KEMRI/CDC HDSS 2017).

Data from the Nairobi Urban HDSS from 2010–2015 demonstrated overall a lower proportion of deaths due to NCDs (14%) compared to the rural based Siaya HDSS but a much higher proportion of deaths due to injuries (19%). The proportion of deaths due to NCDs was relatively constant across wealth quintiles (range: 12.1–15.2%), but the proportion of deaths due to injuries was highest in the poorest quintile (22.8%) as compared to the wealthiest quintile (16.9%). Overall, crude death rates due to both NCDs and injuries demonstrated a clear socioeconomic trend, with increasing death rates associated with increasing level of poverty ([Figure 3b](#)).



[Figure 3b](#) Crude death rates due to NCDs and injuries by wealth quintile in Nairobi Urban HDSS, 2010–2015 (Source: APHRC 2017).

RISK FACTORS FOR NCDIS IN KENYA

In risk factor modeling from GBD 2016, behavioral and metabolic risk factors, such as tobacco, alcohol, obesity and raised blood pressure, accounted for only 21% of DALYs from NCDI conditions in Kenya. In this model, 73% of all NCDI DALYs were not attributable to the examined risk factors. In regard to DALYs associated with NCDs alone, 23% of these DALYs were attributed to behavioral and metabolic risk factors, while the four traditional behavioral risk factors were associated with 13% of all NCD DALYs. In the categories of digestive diseases, neurologic diseases, musculoskeletal diseases, and other NCDs, virtually none of the risk factor profile could be attributed to behavioral or metabolic causes (Figure 4). For injuries and mental and substance use disorders, only 10–15% of the risk factor profile was attributed to behavioral causes.

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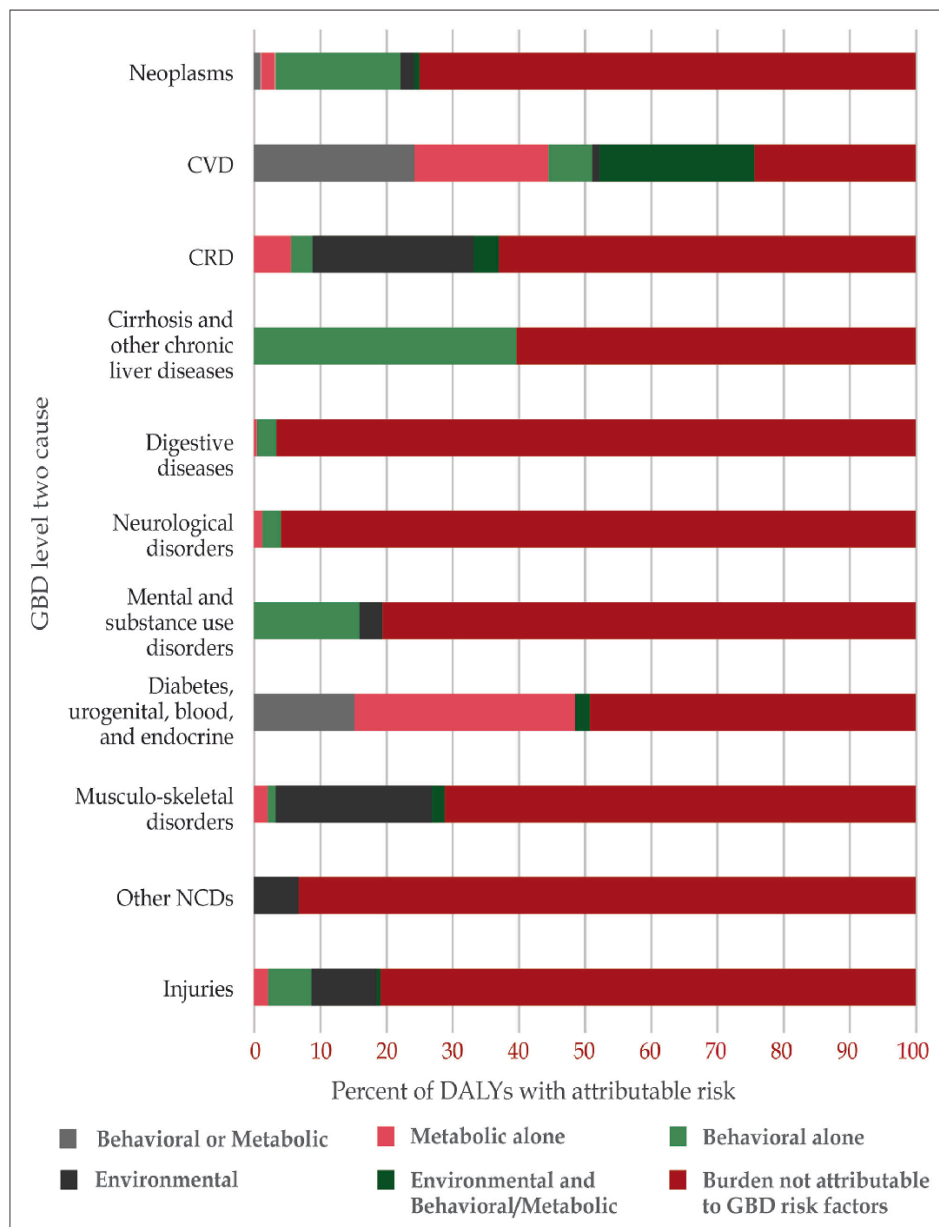


Figure 4 Proportion of disability-adjusted life years in Kenya due to risk factor groups in each NCDI disease category (GBD 2016).

Although the categories of neoplasms and cirrhosis had a higher proportion of attributable risks to behavioral risk factors (20% and 53%, respectively), which likely represents the relationship of smoking with lung cancer and alcohol use with cirrhosis, it is notable that the vast majority of neoplasms and almost half of cases of cirrhosis were caused by other risk factors, such as chronic infections (human papilloma virus, Epstein Barr virus, hepatitis B and C) or genetic

predispositions. Chronic respiratory diseases had the largest component of risk factors attributable to the environment, presumably through air pollution and indoor pollution due to cooking using solid fuels (such as wood, crop wastes, charcoal, coal, and dung) and kerosene in open fires and inefficient stoves. Although the categories of both cardiovascular disease and diabetes had the highest proportion of metabolic risk, metabolic risk alone remained less than half of the risk factor profile for each of these categories, which suggests a large component of non-metabolic related disease conditions, such as rheumatic heart disease, cardiomyopathies, and type 1 diabetes, within these categories.

SERVICE AVAILABILITY FOR NCDIS IN KENYA

Overall, 34% of facilities surveyed in the SARA 2013 health facility survey were considered ready for NCD services as measured by the presence of standard precautions, basic amenities, basic equipment, and essential medicines. The level of readiness was 51% of hospitals, 51% at health centers, 36% at dispensaries, and 21% at medical clinics. A greater proportion of public facilities (42%) were considered ready as compared to private not-for-profit (34%) and private for-profit (22%) facilities. Overall, all facilities had available 37.1% of components of this readiness package, and only 4.9% of facilities had all components available. Compared to other disease areas, essential NCD medications were less available at both hospitals (32%) and primary care facilities (25%) than medications for malaria (65% and 55%, respectively), tuberculosis (TB) (55% and 51%, respectively), and HIV (35% and 47%, respectively) (Figure 5).

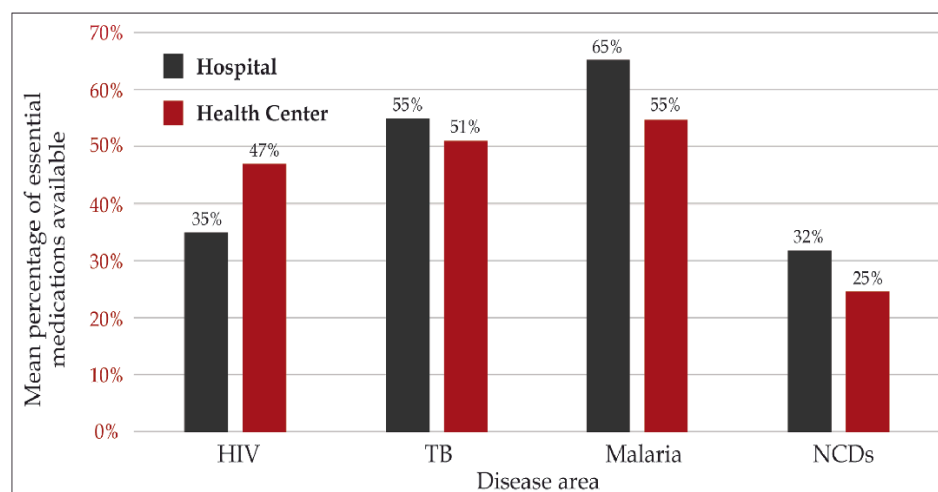


Figure 5 Mean availability of essential medications for NCDs compared to HIV, TB, and malaria (Service Availability and Readiness Assessment, 2013).

Among medications on the national essential medicines list, there was low availability of medicines in both urban (31%) and rural health facilities (22%) (Figure 6a). Only glucose injectable, furosemide, and paracetamol were more available in the public health facilities. Overall, counties with a higher proportion of the population living in the poorest billion had a lower mean number of tracer NCD medications available as compared to counties with a lower proportion of population living in the poorest billion ($r = -0.386$, $p = <0.01$) (Figure 6b). Only the availability of aspirin and insulin were not correlated with poverty level in the counties.

The distribution of NCDI referral services listed in Kenya Essential Package for Health (KEPH) and specialty physicians throughout the country has not been well quantified, though such resources are limited and largely concentrated in urban areas. Expert opinion provided by the Commission indicates that currently there were a limited number of referral level services in the public sector in Kenya. These include six cardiac surgery centers, twelve centers with capacity for chemotherapy, and six radiotherapy centers, though only one radiotherapy center in the public sector. Through the "Changing Diabetes in Children" project, there are eight "hubs" providing care for type 1 diabetes in the public sector, with 16 "spokes". Dialysis is more readily available, with approximately 294 centers around Kenya. Computed tomography (CT) is available at 17 public facilities, and magnetic resonance imaging (MRI) at 20 public facilities. Histopathology services are available at most

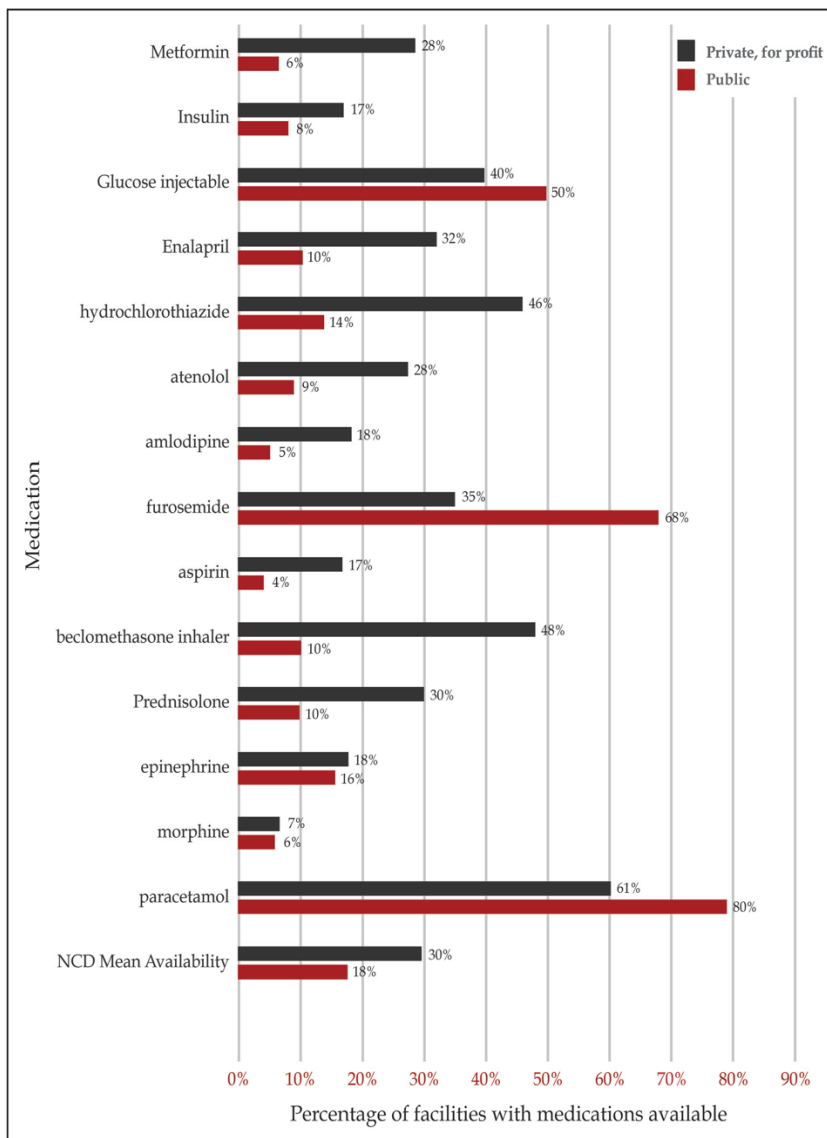


Figure 6a NCD medication availability in all facilities by urban or rural categorization (Service Availability and Readiness Assessment, 2013).

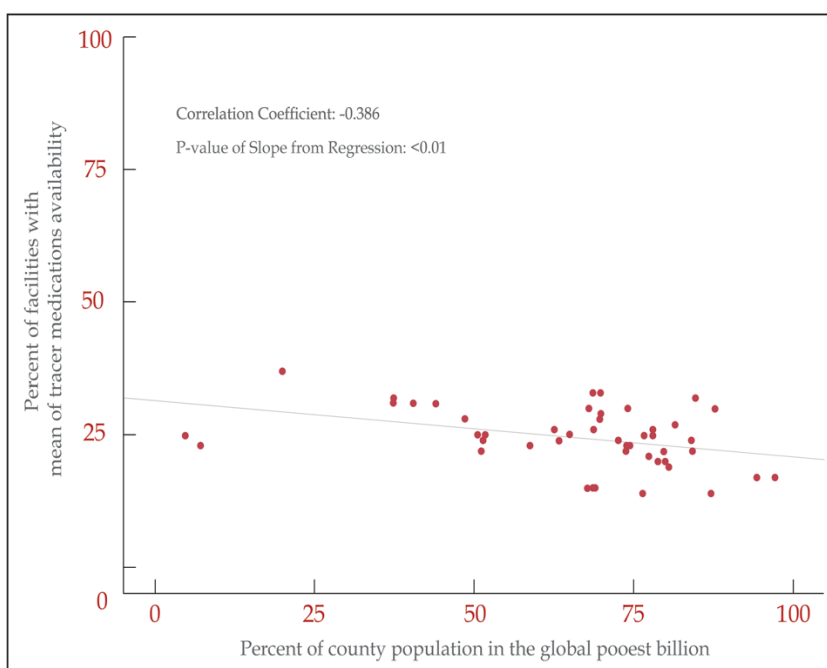


Figure 6b Percent of facilities in each county with the mean number of tracer medications available for NCDs by the percent of the county's population living in the global poorest billion (Sources: Service Availability and Readiness Assessment 2013 and Oxford Poverty & Human Development Initiative).

major hospitals, and 11 county hospitals have integrated palliative care services and serve as training and mentorship sites for county hospitals [29, 30]. Availability of these services as well as specialist physicians per 100,000 population were calculated by the Commission and full results are available in the Kenya NCDI Poverty Report [22].

ACCESS AND COVERAGE OF BASIC NCDI SERVICES

According to the Kenya STEP survey 2015, 55.8% of respondents had never had their blood pressure measured in the past, and 87.8% had never had their blood sugar measured in the past [14]. Access to screening for both hypertension and diabetes was related to wealth quintile, with progressively higher proportions never previously screened with increasing poverty level (Figure 7). This relationship was also seen when comparing urban and rural populations, with a higher proportion of individuals never previously screened in rural areas for both hypertension (60.7% vs. 48.1%) and diabetes (89.6% vs. 84.8%). Of those patients found to have hypertension, access to treatment was associated with wealth quintile, with poorer populations less likely to be on treatment (Figure 7). A higher proportion of patients were screened and on treatment for hypertension from urban areas (24.8%) than from rural areas (20.3%) [14].

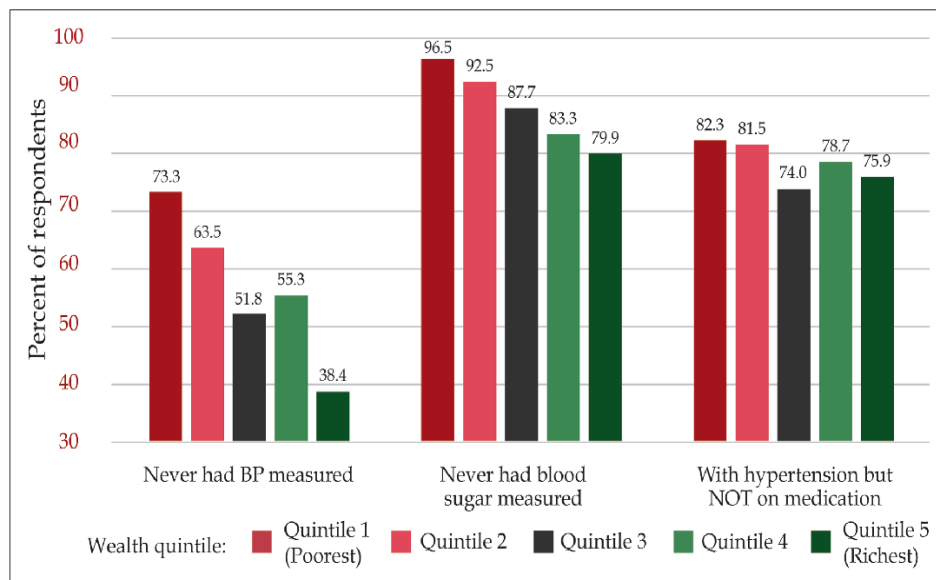


Figure 7 Access to diagnosis for hypertension and diabetes and treatment for hypertension, by wealth quintile (STEPS 2013).

In regard to coverage of other NCDI services, the distribution of cancer screening suggested a socioeconomic trend. In the Kenya DHS 2014, cancer screening was higher among those in the wealthiest quintile as compared to those in the poorest quintile for breast cancer (22.7% vs. 4.4%, respectively), cervical cancer (22.9% vs. 4.4%), and prostate cancer (3.9% vs. 1.5%) [18]. Screening for each of the above cancers was also found to be higher in urban compared to the rural areas.

CURRENT SPENDING ON NCDIS IN KENYA

According to the Kenya National Health Account (NHA) Fiscal Year (FY) 2015/16, total health expenditure (THE) in Kenya was \$3,475,539,658 USD or \$78.60 USD per capita. This THE was 5.2% of nominal gross domestic product, and the government expenditure on health was 6.7% of all government expenditure. Expenditure on NCDs in FY 2015/16 was \$198,568,740 USD, or 5.7% of THE (\$4.48 USD per capita), a decrease from 6.2% in FY 2012/13. Of this expenditure on NCDs, 45% of revenue for financing schemes was from the government, 31% from employers, 20% from households, and 5% from international sources. Two-fifths (40%) of the expenditures for NCDs were incurred in government health facilities while 34% was incurred in private health facilities. About half (48%) of NCD expenditures were for outpatient curative care services, 29% for inpatient curative care, and 9% for preventive care. Expenditure on injuries in 2015/16 was an additional 3.7% of THE (\$2.91 USD per capita), a decrease from 4.1% in FY 2012/13 [28].

PRIORITY NCDI INTERVENTIONS FOR UNIVERSAL HEALTH COVERAGE

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The Commission undertook a process to prioritize among NCDI conditions for the Kenya health sector based on principles of priority setting established by the WHO Consultative Group on Equity and Universal Health Coverage (UHC) [31]. The Commission analyzed and ranked NCDI conditions based on the estimated burden of disease of each condition in Kenya as measured by DALYs in the GBD 2016 [23]. The severity of each condition was measured using the average years of life lost (YLL) per death, and the disability of each condition was measured using the years of life with disability (YLDs) per incident case. The impact in Kenya compared to high-income countries was estimated for each condition by comparing the rate of DALYs per 100,000 population. A total of 190 NCDI conditions from the GBD database were analyzed by these metrics, and a summary score was provided to each condition according to the average of the ranking quartiles on each metric. The 50 conditions with the highest summary score were then reviewed by a sub-committee of the Commission. The commissioners then selected a final set of 14 conditions based on: 1) their ability to contribute significantly to adverse health and economic consequences in Kenya, 2) how feasible and effectively they can be controlled in Kenya, and 3) their being complementary to ongoing strategy and efforts by the Government of Kenya (GoK) as per the national health policy and NCD strategic plan. The selected conditions are shown in [Table 1](#).

DISEASE CATEGORY	PRIORITIZED DISEASE/CONDITION
Respiratory	Asthma
	Chronic obstructive pulmonary disease
Cardiovascular – behavioral & metabolic etiologies	Hypertension, Hypertensive heart disease, Ischemic heart disease, hemorrhagic stroke, ischemic stroke
Cardiovascular – other etiologies	Rheumatic heart disease
Endocrine	Diabetes mellitus (type 1 and 2)
Cancers	Cervical cancer
	Burkitt lymphoma (non-Hodgkin lymphoma)
	Breast cancer
Mental Health	Major depressive disorder
Neurologic	Epilepsy
Congenital	Sickle cell disorders
Liver	“Cirrhosis” – etiologies include hepatitis B, hepatitis C, alcohol, other causes
Surgical & Injuries	Motor vehicle road injuries
	Assault

Table 1 Selected priority NCDIs for service expansion.

Information regarding evidence-based and cost-effective health sector interventions for NCDIs was obtained from Disease Control Priorities 3 (DCP3) [32]. The unit cost for each intervention was provided on average across low-income countries, which is described in greater detail elsewhere [33]. Tradable costs were adjusted for the cost of health sector expenditure in Kenya, and an estimated 50% indirect cost was added to the total cost for each intervention. These interventions were reviewed by the Commission for 1) alignment with stated NCDI priority conditions, and 2) feasibility and desirability in the Kenya context. Each intervention was assigned a baseline coverage in Kenya, estimated from existing data sources as well as expert experience from the commissioners. With consultation from national and regional health managers, the Commission then assigned a feasible target coverage for each intervention by the year 2030. The total cost of implementing these interventions and premature deaths averted was then calculated [34].

The total annual cost of the incremental increase in coverage represented by this package is estimated to be \$520,146,154 USD, or approximately KSh 54.7 billion ([Table 2](#)). This package of

Table 2 Selected priority interventions for NCDIs with cost-effectiveness rating, financial risk protection rating, equity rating, total cost for estimated population in need, estimated baseline coverage, assigned target coverage, and calculated incremental cost.

CONDITION	INTERVENTION	COST EFFECT- IVENESS RATING	FINANCIAL RISK PROTECTION RATING	EQUITY RATING	TOTAL COST	BASELINE COVERAGE 2018	TARGET COVERAGE 2030	INCREMENTAL COST	HEALTH SYSTEM LEVEL
Cirrhosis	Screening and brief intervention for alcohol use disorder	3	2	1					
Respiratory	Low-dose inhaled corticosteroids and broncho-dilators for asthma and for selected patients with COPD	1	3	1	262,690,039	0.16	0.5	89,314,613	Health Center
Respiratory	Management of acute exacerbations of asthma and COPD using systemic steroids, inhaled beta-agonists, and, if indicated, oral antibiotics and oxygen therapy	1	4	1	165,654,576	0.16	0.5	56,322,556	First-Level Hospital
Respiratory	Mass media for awareness on handwashing and household air pollution health effects	0	1	1	1,768,986	0.1	0.8	1,238,290	Population
Respiratory	Tobacco cessation counseling and use of nicotine replacement therapy in certain circumstances	4	2	1	46,322,061	0.07	0.6	24,550,692	Health Center
Respiratory	Mass media messages concerning use of tobacco and alcohol	4	1	1	1,768,986	0.61	0.8	336,107	Population
Breast Cancer	Treat early stage breast cancer with appropriate multimodal approaches, including generic chemotherapy, with curative intent, for cases that are referred from health centers and first-level hospitals following detection using clinical examination	4	4	1	1,496,070	0.1	0.8	1,047,249	Referral Hospital
Cervical Cancer	Opportunistic screening for cervical cancer using visual inspection or HPV DNA testing and treatment of precancerous lesions with cryotherapy	3	3	1	8,295,680	0.14	0.6	3,816,013	Health Center
Cervical Cancer	School-based HPV vaccination for girls	3	3	1	10,835,837	0.02	0.8	8,451,953	Community
Cervical Cancer	Early detection and treatment of early-stage cervical cancer	0	4	1	380,650	0.6	0.8	114,195	First-Level Hospital
Cancer- Lymphoma/ leukemia	Treatment of early-stage childhood cancers (such as Burkitt and Hodgkin lymphoma, acute lymphoblastic leukemia, retinoblastoma, and Wilms tumor) with curative intent in pediatric cancer units or hospitals	3	5	1	205,957	0.1	0.5	82,383	Referral Hospital
Cardiovascular	Long term management of ischemic heart disease, stroke, and peripheral vascular disease with aspirin, beta blockers, ACEi, and statins (as indicated) to reduce risk of further events	2	2	1	109,888,784	0.8	1.0	32,966,635	Health Center
Cardiovascular	Mass media messages concerning healthy eating or physical activity	4	1	1	1,768,986	0.23	0.8	1,008,322	Population
Cardiovascular	Opportunistic screening for hypertension for all adults and initiation of treatment among individuals with severe hypertension and/or multiple risk factors	1	1	1	20,334,580	0.442	0.8	7,279,780	Health Center
Cardiovascular	Screening and management of hypertensive disorders in pregnancy	1	3	3	452,107	0.6	0.8	180,843	Health Center
Cardiovascular	Provision of aspirin for all cases of suspected acute myocardial infarction	4	2	1	4,330	0.1	0.5	1,732	Health Center

interventions would represent a 2.6-fold increase in the current expenditure on NCD services as reported by the NHA 2015/16, which would comprise 15.0% of the current total health expenditure. Overall, this package of interventions, which includes outpatient, inpatient, surgical, mental health, rehabilitation, and palliative care services would represent an incremental investment of \$11.76 per capita annually. Using mortality impact estimation methodology described by the DCP3 group, these interventions, if implemented to target coverage, are projected to avert 9,322 premature deaths per year by the year 2030. This figure represents an approximate 10% reduction in expected premature deaths by the year 2030 (according to 2015 death rates).

DISCUSSION

The findings of this Commission suggest that NCDIs comprise a large share of the burden of disease in Kenya and affect the population at younger ages than commonly believed. The burden of NCDI conditions is very diverse, and the majority of NCD DALYs in Kenya are due to conditions other than the four emphasized in global monitoring frameworks. While behavioral risk factors have a large attributable risk for NCDs, the findings of this Commission show that most of the NCDI disease burden in Kenya cannot be directly attributed to individual lifestyle choices using existing data sources. Data from HDSS sites from both rural and urban contexts demonstrate an equal, if not higher, proportion of deaths due to NCDIs in the poorest as compared to wealthiest quintiles. Furthermore, crude death rates among the poor were more than double for NCDs and triple for injuries than that among the wealthier populations.

The Kenyan National Strategy for the Prevention and Control of NCDs 2015–2020 went beyond the WHO GAP framework in including additional conditions, such as violence and injuries, palliative care, mental disorders, cognitive impairment, renal disorders, hepatic disorders, endocrine disorders, neurological conditions, hemoglobinopathies, gastroenterological, musculoskeletal, skin disorders, oral diseases, disabilities including visual and hearing impairment, and genetic disorders [35]. The Kenya Essential Package for Health also followed this model by developing a comprehensive package of services for NCDIs at multiple tiers of the health system [36]. However, this Commission found that availability of key medications and readiness of NCD services remains limited and inversely related to the poverty level of regions. Coverage of basic NCDIs, such as diagnosis and treatment of hypertension and diabetes or cancer screening, is low, and is inversely related to wealth. Domestic financing for NCDIs was also limited and not commensurate to the burden.

The interventions selected and prioritized by this Commission will require design, implementation, integration, and scale of a complex set of health sector interventions, some of which already exist within the health care system, and others that have yet to be introduced. Although this package of interventions for NCDIs is quite comprehensive, including surgical, mental health, rehabilitation, and palliative care services, it would represent only a 15.0% increase in total health expenditure or \$11.76 per capita annually. This level of additional expenditure for NCDIs may not be unreasonable in the setting of recent recommendations for government expenditure on health care, such as 5% of GDP or a per capita expenditure of \$86 USD in low-income countries [37].

These interventions, if implemented to target coverage, are projected to avert 9,322 premature deaths per year by the year 2030. This figure represents an approximate 10% reduction in expected premature deaths in the year 2030 (according to 2015 death rates). However, although this figure provides a reasonable estimate of averted deaths, given the greater number of interventions selected by the Kenya NCDI Poverty Commission than the DCP3 high-priority essential package, this figure is likely underestimated. Furthermore, this analysis does not include averted morbidity, which would be considerably greater than averted mortality, and provide substantial benefit to many more individuals, particularly given the emphasis on interventions for severe conditions affecting those at younger ages.

The majority of interventions selected for introduction or scale up would be applied at the primary care or health center level. Essential components to the introduction and scale-up of these interventions are many, and would include infrastructure, staffing, training, guidelines, medications, equipment, diagnostics, and referral networks. However, most of these interventions

exist at some baseline level in public health sector facilities, though availability and readiness may vary dramatically. Integration with existing infrastructure and personnel for other chronic diseases, such as antiretroviral therapy for HIV/AIDS, maternal and child services and surgical services may facilitate integration of other chronic disease services for chronic NCDs and mental health conditions [38].

Health system interventions alone are not sufficient to prevent the risk and impact of NCDIs as well as provide care for NCDs on the Kenyan community, and a truly comprehensive response to NCDIs in Kenya requires a whole-of-government approach. In conjunction with the findings of this Commission, a national NCD inter-sectoral coordinating mechanism was launched to foster inter-sectoral interventions and to harness the support and synergies from outside of the health sector. This inter-sectoral committee adopted the recommendations of this Commission and is working towards broadening Kenya's attention beyond the traditional NCDI behavioral risk factors and a more comprehensive approach rooted in equity. The recommended interventions require local adaptation and integration into existing health services platforms, coupled with development and strengthening of human resource capacity, supply chains, and referral pathways.

Mitigating the impoverishing effects of NCDIs will require the expanded coverage of the national social insurance program, establishment and strengthening of social safety nets for the poor, and increased focus on more equitable access to both preventive and curative health services through coherent cross-sectoral policies and plans. There is need to expand investment in the NCDI response via increases in direct domestic financing through capitation, insurance revenues, and innovative financing mechanisms and partnerships. With these recommendations, this Commission believes that an expansive reframing of NCDIs will allow for a comprehensive and equitable response to NCDIs in hopes of realization of the broader goal of UHC for the Kenyan population.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Gene Bukhman and Neil Gupta contributed equally to this manuscript. All the authors participated in the preparation of the manuscript.

AUTHOR AFFILIATIONS

Kibachio Mwangi  orcid.org/0000-0003-3725-1762

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya
Institute of Global Health, Faculty of Medicine, University of Geneva, Geneva, Switzerland
World Health Organization (WHO) South Africa Country Office, South Africa

Gladwell Gathecha  orcid.org/0000-0001-9669-0226

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Mary Nyamongo  orcid.org/0000-0001-8359-5596

African Institute of Health and Development, Nairobi, Kenya

Sylvester Kimaiyo  orcid.org/0000-0003-4957-1253

Academic Model Providing Access to Healthcare, Eldoret, Kenya

Jemima Kamano  orcid.org/0000-0003-2179-8202

Academic Model Providing Access to Healthcare, Eldoret, Kenya

Fredrick Bukachi

Department of Clinical Medicine and Therapeutics, University of Nairobi, Nairobi, Kenya

Frank Odhiambo  orcid.org/0000-0003-3056-8425

Kenya Medical Research Institute, Nairobi, Kenya

Hellen Meme

Kenya Medical Research Institute, Nairobi, Kenya

Hussein Abubakar

Field Epidemiology and Laboratory Training Program, Nairobi, Kenya

Nelson Mwangi

Field Epidemiology and Laboratory Training Program, Nairobi, Kenya

Joyce Nato  orcid.org/0000-0003-3292-8834

World Health Organization Country Office, Nairobi, Kenya

Samuel Oti  orcid.org/0000-0003-1035-9511

International Development Research Center, Nairobi, Kenya

Catherine Kyobutungi  orcid.org/0000-0002-5344-5631

African Population and Health Research Center, Nairobi, Kenya

Marylene Wamukoya  orcid.org/0000-0002-2900-9178

African Population and Health Research Center, Nairobi, Kenya

Shukri F. Mohamed  orcid.org/0000-0002-8693-1943

African Population and Health Research Center, Nairobi, Kenya

Emma Wanyonyi

International Institute for Legislative Affairs, Nairobi, Kenya

Zipporah Ali  orcid.org/0000-0003-3643-0304

Kenya Hospices and Palliative Care Association, Nairobi, Kenya

Loise Nyanjau  orcid.org/0000-0002-9608-8494

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Ann Nganga  orcid.org/0000-0002-6217-6955

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Dorcas Kiptui

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Alfred Karagu  orcid.org/0000-0003-0321-9879

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Mary Nyangasi  orcid.org/0000-0003-1889-0702

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Valerian Mwenda  orcid.org/0000-0002-1956-7440

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya

Martin Mwangi  orcid.org/0000-0002-5398-3472

Division of Non-Communicable Diseases, Ministry of Health, Nairobi, Kenya;

Field Epidemiology and Laboratory Training Program, Nairobi, Kenya

Aaron Mulaki

RTI International, Nairobi, Kenya

Daniel Mwai  orcid.org/0000-0002-6750-9480


School of Economics, University of Nairobi, Nairobi, Kenya

Paul Waweru  orcid.org/0000-0001-6312-2126

Kenya National Bureau of Statistics, Nairobi, Kenya


Mamka Anyona  orcid.org/0000-0002-4704-9018

Program in Global Non-Communicable Diseases and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, USA

Peninah Masibo  orcid.org/0000-0001-5404-1711

Global Programs for Research and Training Affiliate of The University of California San Francisco, USA;

Moi University School of Public Health, Eldoret, Kenya

David Beran  orcid.org/0000-0001-7229-3920

Division of Primary Care Medicine, Geneva University Hospital and University of Geneva, Geneva, Switzerland

Idris Guessous  orcid.org/0000-0002-0491-6089

Institute of Global Health, Faculty of Medicine, University of Geneva, Geneva, Switzerland;

Division of Tropical and Humanitarian Medicine, University of Geneva and Geneva University Hospitals, Geneva, Switzerland

Matt Coates  orcid.org/0000-0002-8474-4992

Program in Global Non-Communicable Diseases and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, USA

Gene Bukhman  orcid.org/0000-0003-4500-7903

Program in Global Non-Communicable Diseases and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, USA;

NCD Synergies, Partners in Health, Boston, USA

Neil Gupta  orcid.org/0000-0003-3470-5351

Program in Global Non-Communicable Diseases and Social Change, Department of Global Health and Social Medicine, Harvard Medical School, Boston, USA;

NCD Synergies, Partners in Health, Boston, USA

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Research



Socio-economic and demographic determinants of non-communicable diseases in Kenya: a secondary analysis of the Kenya stepwise survey

Kibachio Joseph Mwangi, Valerian Mwenda, Gladwell Gathecha, David Beran, Idris Guessous, Oren Ombiro, Zachary Ndegwa, Peninnah Masibo

Corresponding author: Kibachio Joseph Mwangi, Faculté de Médecine, Université de Genève, Genève, Suisse. kibachiojoseph@gmail.com

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Socio-economic and demographic determinants of non-communicable diseases in Kenya: a secondary analysis of the Kenya stepwise survey

Kibachio Joseph Mwangi^{1,2,&}, Valerian Mwenda^{2,3}, Gladwell Gathecha², David Beran⁴, Idris Guessous^{1,5}, Oren Ombiro^{2,6}, Zachary Ndegwa², Peninnah Masibo⁷

¹Faculté de Médecine, Université de Genève, Genève, Suisse, ²Division of Non-communicable Disease, Ministry of Health, Nairobi, Kenya, ³Field Epidemiology and Laboratory Training Program, Ministry of Health, Nairobi, Kenya, ⁴Division of

Primary Care Medicine, Department of Primary Care Medicine, Geneva University Hospitals, Geneva, Switzerland, ⁵Division of Tropical and Humanitarian Medicines, Geneva University Hospitals and University of Geneva, Geneva, Switzerland, ⁶Improving Public Health Management for Action (IMPACT) Program, Ministry of Health, Nairobi, Kenya, ⁷Global Programs for Research and Training, University of California, San Francisco, Nairobi, Kenya

&Corresponding author

Kibachio Joseph Mwangi, Faculté de Médecine, Université de Genève, Genève, Suisse

Abstract

Introduction: non-communicable diseases (NCDs) are projected to become the leading cause of death in Africa by 2030. Gender and socio-economic differences influence the prevalence of NCDs and their risk factors. **Methods:** we performed a secondary analysis of the STEPS 2015 data to determine prevalence and correlation between diabetes, hypertension, harmful alcohol use, smoking, obesity and injuries across age, gender, residence and socio-economic strata. **Results:** tobacco use prevalence was 13.5% (males 19.9%, females 0.9%, $p<0.001$); harmful alcohol use was 12.6% (males 18.1%, females 2.2%, $p<0.001$); central obesity was 27.9% (females 49.5%, males 32.9%, $p=0.017$); type 2 diabetes prevalence 3.1% (males 2.0%, females 2.8%, $p=0.048$); elevated blood pressure prevalence was 23.8% (males 25.1%, females 22.6%, $p<0.001$), non-use of helmets 72.8% (males 89.5%, females 56.0%, $p=0.031$) and seat belts non-use 67.9% (males 79.8%, females 56.0%, $p=0.027$). Respondents with <12 years of formal education had higher prevalence of non-use of helmets (81.7% versus 54.1%, $p=0.03$) and seat belts (73.0% versus 53.9%, $p=0.039$). Respondents in the highest wealth quintile had higher prevalence of type II diabetes compared with those in the lowest (5.2% versus 1.6%, $p=0.008$). Rural dwellers had 35% less odds of tobacco use (aOR 0.65, 95% CI 0.49, 0.86) compared with urban dwellers, those with ≥ 12 years of formal education had 89% less odds of tobacco use (aOR 0.11, 95% CI 0.07, 0.17) compared with <12 years, and those belonging to the wealthiest quintile had 64% higher odds of unhealthy diets (aOR 1.64, 95% CI 1.26, 2.14). Only 44% of respondents with type II diabetes and 16% with hypertension were aware of their diagnosis. **Conclusion:** prevalence of NCD risk factors is high in Kenya and varies across socio-demographic attributes. Socio-demographic considerations should form part of multi-sectoral, integrated approach to reduce the NCD burden in Kenya.

Introduction

Non-communicable diseases (NCDs) are currently the leading cause of both morbidity and mortality worldwide, with indications that this trend will continue increasing [1]. Low- and middle-income countries (LMIC) contribute to more than 80% of global premature NCD deaths [2]. Almost 30 percent of NCD deaths in LMICs occur among people under age 60 years at the peak of their economic productivity compared to only 13 percent in high-income countries [3,4]. This has a major impact on economic livelihoods of individuals, their families and health systems due to their long, chronic courses, need for lifelong treatment and follow-up and need for advanced methods for management of complications [5]. With the exception of the African region, globally NCD mortality exceeds that of communicable, maternal, perinatal and nutritional conditions combined [6]. By 2030, NCDs are estimated to contribute to three times as many disability-adjusted life years (DALYs) and nearly five times as many deaths as communicable diseases, maternal, perinatal and nutritional conditions combined in LMICs [7].

Impact of NCDs on individual, societal and national economic development is higher in LMICs due to coexistence with an equally high burden of communicable diseases, reproductive and child health challenges as well as violence and injuries within fragile health systems [8,9]. These countries have poor capacity for diagnosis of NCDs, large-scale public health interventions and management of complications arising from poor treatment or late diagnosis [10].

There are several socio-demographic determinants of the prevalence of NCDs and their risk factors. The major NCD risk factors; tobacco use, harmful use of alcohol, physical inactivity and unhealthy diets, are modifiable behaviors established during adolescence or young adulthood and cause NCDs later in life [11]. High rates of poverty and inequality in the region exacerbate the challenges; living in low-income neighborhoods is an

important precursor for NCD risks factors [9]. Even though NCDs cause two out of three deaths in women and the absolute number of NCD deaths in women is similar to men (16.2 versus 18.4 million), less focus is given to NCDs in women globally compared with reproductive and maternal health [1,3].

Determining how NCD prevalence as well as risk factors differ across different gender, wealth quintiles, education level and place of residence can provide public policy and health authorities with invaluable knowledge on designing and implementing intervention packages and policies to address the NCD pandemic. The survey was carried out in Kenya for the first time in 2015, with collection of data on behavioural risk factors, medical history, physical measurements and biochemical tests. Understanding NCD dynamics across socio-economic strata is vital for planning control programmes. This secondary analysis focused on the relationship between age, gender, residence and socio-economic strata and the prevalence of various NCDs and their risk factors, from the survey findings.

Methods

Overview of STEPS Kenya, 2015: the WHO STEPwise survey is a tool developed by the World Health Organization (WHO) to enable countries to systematically undertake surveillance on NCD risk factors worldwide, with tools and methods that are easily reproducible and enable comparison of results from different countries [12].

Study type, site and population: data for this study were obtained from the 2015 Kenya STEPs survey. The Kenya STEPwise survey was a cross-sectional household survey targeting adults between the ages of 18 and 69 years conducted between April and June 2015 utilizing the WHO STEPwise tool which is a cross-culturally validated survey tool used to assess burden of leading non-communicable diseases and their associated lifestyle risk factors in a nationally representative sample. The focus of the survey was the four main

behavioural risk factors of NCDs (tobacco use, harmful use of alcohol, unhealthy diets and physical inactivity), the four key biological risk factors for NCDs (overweight and obesity, raised blood pressure, raised blood lipids and raised blood glucose) as well as awareness for cervical cancer, burden of unintentional injuries and oral health.

Sampling: this survey involved a three-stage cluster sample design involving selection of clusters from the national sample surveys and evaluation programme (NASSEP V) sampling frame from the Kenya National Bureau of Statistics, developed using the enumeration areas generated from the 2009 Kenya population and housing census. Two-hundred clusters (100 urban and 100 rural) were selected with a uniform sample of 30 households being sampled from each cluster in the second stage and an eligible individual respondent sampled using the Kish grid method of sampling in the third stage.

A total of 6000 households were sampled targeting one individual randomly selected from all eligible household members using the Kish method. Of the 4754 participants who gave consent, a total of 4500 individuals were successfully interviewed giving a response rate of 75%. To produce unbiased estimates, sampling weights were calculated as the inverse or reciprocal of all the selection probabilities at all the stages mentioned above. Further, the weights were adjusted to cover individual non-responses. Post stratification adjustments were done to align with the population projections according to age-sex categories.

Data collection and definitions: the survey entailed a sequential process consisting of three “steps” of information gathering as follows: step 1 entailed interviews on demographic information and selected major health risk behaviors; step 2 involved anthropometric measurements of height, weight, waist and hip circumference as well as blood pressure and heart rate; step 3 involved biochemical measurements of fasting blood

glucose, triglycerides and cholesterol levels. A detailed description of the approach, process and measurements for the Kenya STEPwise survey is available elsewhere [13].

Central obesity was defined as waist-hip ratio of more than 0.85 in men and 0.9 in women. Type II diabetes was defined as fasting blood sugar of 7 mmol/l and above for the first time during the survey, while those with sugars of between 6.0 and 6.9 mmol/l were labeled as prediabetes. Hypertension was defined as systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg. Heavy episodic drinking was defined as six or more standard drinks in a single drinking occasion. Current tobacco use was defined as use of any tobacco products in the past 30 days. Unhealthy diet was defined as intake of less than five servings of fruits and vegetables in a day, addition of salt at the table while eating or intake of processed foods high in salt or addition of sugar to drinks already served with sugar or intake of processed foods or drinks high in sugar, daily. Physical inactivity was defined as obtaining less than 150 min of moderate intensity physical activity throughout the week or less than 75 min of vigorous intensity physical activity throughout the week or less than an equivalent combination of moderate and vigorous intensity derived from WHO definition of physical activity [14]. The WHO risk estimation model for cardiovascular disease (CVD) risk where age, sex, smoking, blood pressure, blood cholesterol and presence of diabetes were used as basis for estimating the 10-year CVD risk that represented a risk of a fatal or non-fatal cardiovascular event (meaning death from or developing cardiovascular disease) A risk at or above 30 percent is considered high and cost-effective to treat.

Data analysis: we conducted a further analysis of the STEPS dataset for the current study. The outcome variables for this study included prevalence of hypertension, heavy episodic drinking, smoking, central obesity, non-use of seatbelts while driving in a vehicle or not wearing helmets while riding a bicycle or motorcycle.

The outcome variables were then compared across the various independent variables used in this study including sex, age, marital status, level of education, occupation, residence and socio-economic status (wealth band). Logistic regression analyses were used to compute adjusted odds ratios (aOR) for each exposure variable while controlling for all the other variables (confounders) in the model. Using the “svy” method in STATA, we created estimates that adjust for the complex, multi-level sampling design, including stratifying by Kenyan regions and enumeration areas. We computed adjusted odds ratios for each exposure variable while controlling for all the other variables in the model with 95% confidence intervals that excluded the null (AOR equal to 1.0) considered statistically significant. This secondary analysis included 4484 respondents after omitting records that had missing values for the independent and dependent variables from the initial survey sample size of 4500 respondents.

Results

Overview of the findings: of the 4484 individuals included in this secondary analysis, 60% were female, 42% had secondary education and above while 13% had no formal education. The mean age was 40.5 years (95%CI: 39.9-41.1 years). Sixty-six percent of the respondents were married, 40% were unemployed while 62% were rural residents (Table 1). Prevalence and correlates of selected NCD risk factors across socio-demographic strata. NCD risk factors distribution varied across socio-demographic strata.

Current tobacco use: compared to females, males had a higher prevalence of current tobacco use (19.9% versus 0.9%, $p < 0.001$). Respondents with less than 12 years of formal education had higher prevalence of tobacco use (12.1 versus 7.6%, $p = 0.044$). Employed respondents had higher prevalence of tobacco use (12.4% versus 6.9%, $p = 0.021$). Tobacco use increased with age (Table 2). Males had eight times higher odds of tobacco use (aOR 7.63, 95% CI 5.63, 10.33)

compared with females. Rural dwellers had 35% less odds of tobacco use (aOR 0.65, 95% CI 0.49, 0.86) compared with their urban counterparts. Respondents with at least 12 years of formal education had 89% less odds of tobacco use (aOR 0.11, 95% CI 0.07, 0.17) compared with those with less education (Table 3).

Harmful use of alcohol: males had a higher prevalence of harmful alcohol use (18.1% versus 2.2%, $p < 0.001$). Respondents with less than 12 years of formal education had higher prevalence of harmful alcohol use (6.3% versus 2.6%, $p = 0.019$). Unemployed respondents had higher prevalence of harmful use of alcohol compared with those in employment (9.3% versus 1.6%, $p = 0.028$). Harmful use of alcohol also increased with age (Table 2). Males had 10 times higher odds of harmful use of alcohol (aOR 9.9, 95% CI 5.3, 18.8) compared with females. Those in employment had 42% less odds of harmful alcohol use (aOR 0.58, 95% CI 0.45, 0.76) compared with the unemployed.

Non-use of safety equipment (helmets and safety belts): males had a higher prevalence of non-use of helmets (89.5% versus 56.0%, $p = 0.031$) and seat belts (79.8 versus 56.0%, $p = 0.027$) compared with females. Respondents with less than 12 years of formal education had higher prevalence of non-use of helmets (81.7% versus 54.1%, $p = 0.03$) and seat belts (73.0% versus 53.9%, $p = 0.039$) compared with those who had spent at least 12 years in school. Non-use of helmets and safety belts increased with age (Table 2).

Central obesity: females had higher prevalence of central obesity (49.5% versus 32.9%, $p = 0.017$) compared with males. We found no difference in prevalence of central obesity between rural and urban residents (43.4% versus 42.0%, $p = 0.780$). There were no differences in central obesity according to the wealth status, but it increased with age (Table 2).

Type 2 diabetes: respondents in the highest wealth quintile had higher prevalence of type II

diabetes compared with those in the lowest (5.2% versus 1.6%, $p = 0.008$). Urban residents had higher prevalence of type 2 diabetes compared with rural residents (3.4% versus 1.9%, $p = 0.041$). Type 2 diabetes prevalence also increased with age (Table 2).

Hypertension and the 10-year CVD risk from multiple NCD risk factors: prevalence of hypertension and 10 years CVD risk had no major variation or correlations across socio-economic strata.

Socio-demographic correlates of the main modifiable NCD risk factors: several independent associations were identified between selected socio-demographic variables and the main modifiable NCD risk factors. Males had eight times higher odds of tobacco use (aOR 7.63, 95% CI 5.63, 10.33) and 10 times higher odds of harmful use of alcohol (aOR 9.9, 95% CI 5.3, 18.8) compared with females. There were however, no differences in their consumption of unhealthy diets compared to the females. Rural dwellers had 34% less odds of physical inactivity (aOR 0.66, 95% CI 0.47, 0.92) and 35% less odds of tobacco use (aOR 0.65, 95% CI 0.49, 0.86) compared with their urban counterparts. They equally had a 40% less odds of heavy episodic drinking compared to the urban dwellers. Respondents with at least 12 years of formal education had 89% less odds of tobacco use (aOR 0.11, 95% CI 0.07, 0.17). Those in the wealthiest quintile had 64% higher odds of unhealthy diets (aOR 1.64, 95% CI 1.26, 2.14) compared with those in the poorest. They also had a 2.5 times higher risk of sedentary lifestyles with physical inactivity compared with those in the poorest quintile. Those in employment had 42% less odds of harmful alcohol use (aOR 0.58, 95% CI 0.45, 0.76) and 32% less odds of current tobacco use compared with the unemployed (Table 3).

Care cascade for diabetes type II and hypertension: of the participants with elevated blood pressure, only 16% were aware of their diagnosis, 4% were currently on hypertension treatment and only 2% had well controlled blood

pressure under medication. Of the participants with elevated blood glucose, 44% were aware of their diagnosis, only 18% of them were on diabetes treatment and of these, only 6% were well controlled. Medication use varied by age and sex; in those diagnosed with type 2 diabetes, 57% of females and 17% of males were using medications at the time of survey, 53.9% among urban residents and 28.3% among rural residents, those in the age bracket 30-44 years reported the highest current use (67 percent). For diagnosed hypertensive respondents, 24% of women and 18% of men were taking anti-hypertensive medication with only 2.1% of them achieving the desired control (Figure 1).

Discussion

We noted differences in NCD prevalence and risk across gender, age and place of residence. More males had higher prevalence of harmful alcohol and tobacco use; females had higher prevalence of central obesity. Less educated respondents had higher prevalence of non-use of safety belts and helmets during transportation. Elevated blood glucose was more prevalent in the wealthiest quintile compared with the lowest. Gender, residence, education level and wealth status were independently associated with various NCD risk factors. Awareness, treatment and achievement of control were low for both elevated blood pressure and blood glucose. This analysis focuses on eight out of the nine items identified for follow-up and surveillance by the WHO global action plan for NCDs; reduction in mortality from the main NCDs, reduction in alcohol, tobacco use, unhealthy diets, physical inactivity, diabetes, hypertension and obesity as well as increase availability of treatment [15]. This study identified various socio-demographic attributes of the various NCD risk factors, that are amenable to public health to enable Kenya to attain the stated targets. While the gender, education and rural urban dwelling have been demonstrated as risk factors of NCD in other studies, the marked difference in this analysis warrants their deliberate consideration in

preventive and curative policies in an integrated, multi-sectoral and whole of government approach.

Males had higher prevalence of smoking and harmful alcohol use compared to females; this gender difference has been consistent in previous studies and surveys [16,17]. Observed differences in drug and substance use between the genders is as a result of interactions among biological, environmental, sociocultural and developmental influences [18]. While this trend has been observed in various settings, an increase in tobacco use among female youths in LMICs has been noted [19]. The gender difference in tobacco use is less among the youth than in adults; the global youth tobacco survey Kenya 2013 reported tobacco use prevalence of 12.8% for boys and 6.7% for girls [20].

Central obesity has been shown to be a better marker of cardiovascular and other NCD risk compared to body mass index [21]. In this study, females and older individuals had higher prevalence of central obesity. A study in Saudi Arabia also identified sex and age as important factors associated with obesity [22]; the global burden of disease prevalence of overweight and obesity study in 2013 found a lower difference, 37.0% in men and 38.0% in women [23]. We found no difference in central obesity prevalence across residence or wealth strata. This may be as a result of urbanization of rural areas and the expansion of the peri-urban territories, eliminating the expected difference.

Non-use of protective gear during transportation differed by level of education; more educated respondents were more likely to use helmets or seat belts when travelling compared to those with less education. This may be due to low-risk perception and safety awareness as well as higher prevalence of harmful alcohol use among those with less education [24]. Sex, education level, residence and wealth status were noted as the main determinants of current tobacco use, harmful use of alcohol, low physical activity and unhealthy diets. Male sex was associated with

tobacco and harmful alcohol use, higher wealth was associated with unhealthy diets and being more educated was negatively associated with alcohol and tobacco use. Males are more prone to risky lifestyles; this may be partly reduced through education. Wealthier residents, especially in urban areas, tend to adopt unhealthy eating habits, as a lifestyle change as well as availability of unhealthy foods. These associations have been observed in other studies as well [25-27].

Majority of the respondents with hypertension or type 2 diabetes were not aware of their diagnosis and even among those aware, most were neither on treatment nor controlled for those already on treatment. In addition to low-risk perception by the patients regarding the complications arising from these two conditions [28], this may also be a result of the health care system that is not optimized to tackle non communicable diseases especially at the primary care level. Integration of NCD care at the primary care level may foster better awareness, uptake of early diagnosis and compliance to treatment especially for the men. There was noted a higher proportion of women on treatment for hypertension and diabetes. This may reflect a poor health seeking behavior of Kenyan men as shown in other studies of seeking health among men and women and may explain the higher proportion of men with long term complications of diabetes like amputations compared to women in the tertiary hospitals in Kenya.

Limitations and strengths: self-reporting for some variables, for instance use of safety belts and helmets, alcohol intake, smoking and dietary history were liable to information and recall bias. However, several outcome variables were measured during the survey, including fasting blood sugar, blood pressure and waist-hip circumference. To improve recall, food cards with portion sizes estimation were used during administration of the food frequency questionnaire while picture sample alcoholic beverages were used to estimate alcohol consumption. Due to the limitation of the survey

tools, it was not possible to identify the individual factors behind some of our findings, for instance, the reasons for non-use of medications for diagnosed diabetic or hypertensive patients. Finally, exclusion of participants with missing data could have prevented us from identifying important differences in NCD risk factor prevalence in the Kenyan population.

This being a dataset from a nationally representative survey on NCD risk factors, the findings may be generalized to the entire Kenyan population and considering that the analysis focused on all the main NCD risk factors identified by WHO in the global action plan for NCDs; these findings are vital in policy evaluation and formulation within Kenya. They are also comparable to similar WHO member states who have deployed the STEPS questionnaire. By identifying the socio-demographic determinants of the NCD risk factors, this analysis offers opportunities for 'quick wins' in the public health response to NCDs in Kenya.

Conclusion

Socio-demographic factors are important determinants of NCD and risk factor prevalence in Kenya. Addressing these determinants requires a multisectoral, whole-of-government and whole-of-society approach as some enablers of behavior change are in jurisdictions beyond the control of the ministry of health. An emphasis on universal basic education access (up to secondary level) is desirable to reduce alcohol and tobacco use as well as improve road safety. Targeted advocacy on physical inactivity and unhealthy diets especially to the urban dwellers and wealthier individuals is required to foster behavior change and adoption of healthier lifestyles. Equally, improvement of the built environment in urban settings to enhance physical activity as well as the creation of open spaces with improved security and access should be considered to improve uptake of physical activity especially in urban settings. Safe and accessible walkways may also reduce the use of

motorized transport in urban settings thus improving the uptake of physical activity.

As part of improving treatment outcomes, opportunities for early detection and linkages to treatment and follow-up for hypertension and diabetes, especially among men is required. Integration of NCDs into existing public health programs to take advantage of synergies and broaden opportunities of awareness creation, diagnosis and linkage to care is also essential. Access to information and care especially at the primary care level would go a long way to halt and reverse the burden of non-communicable diseases. Information may need to be customized to the understanding of the individuals and delivered in different platforms to facilitate behavior change. Workplace wellness program focusing on awareness, early detection, treatment linkages and compliance can improve NCD outcomes.

What is known about this topic

- *Gender and socio-economic differences influence the prevalence of NCDs and their risk factors;*
- *Low levels of education is associated with higher prevalence and risk factors of NCD like tobacco use, harmful alcohol use, non-use of helmets and seat belts.*

What this study adds

- *Living in low-income neighborhoods is an important precursor for NCD risks factors. High rates of poverty and inequality exacerbate this challenge;*
- *The majority of individuals living with hypertension or type 2 diabetes were not aware of their diagnosis and even among those aware, most were neither on treatment nor well controlled;*
- *Medication use and compliance for those diagnosed with type 2 diabetes and hypertension varies by age, gender and locality with rural dwellers being at a higher risk of not being on treatment for elevated blood glucose and hypertension*

indicating geographical or health system related barrier to access for NCDs care.

Competing interests

The authors declare no competing interests.

Authors' contributions

JK conceived the study idea and selected the variables of interest; JK, VM and OO undertook the statistical analysis; GG, ZN, PM, DB and IG contributed, reviewed and restructured the manuscript. All the authors have read and agreed to the final manuscript.

Tables and figure

Table 1: socio-demographic characteristics of the survey population, Kenya STEPS, 2015

Table 2: prevalence of various NCD risk factors across demographic and socio-economic strata, Kenya STEPS, 2015

Table 3: socio-demographic determinants of the main modifiable NCD risk factors, Kenya STEPS, 2015

Figure 1: management cascade for type II diabetes mellitus and hypertension in Kenya from awareness to control

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Table 1: socio-demographic characteristics of the survey population, Kenya STEPS, 2015		
Characteristic	Weighted, n	% proportions (95% CI)
Gender		
Male	1791	39.9 (38.3, 42.0)
Female	2693	60.1 (57.8, 61.9)
Age groups		
18-29	2062	46.0 (43.6, 48.4)
30-39	1045	23.3 (21.6, 25.1)
40-49	695	15.5 (14.1, 17.0)
50-59	443	9.9 (8.8, 11.0)
60-69	239	5.3 (4.7, 6.1)
Marital status		
Not married	1039	23.2 (21, 25.5)
Married	2938	65.5 (63.1, 67.8)
Formerly married	507	11.3 (10, 12.7)
Residence		
Rural	2776	61.9 (59.4, 64.4)
Urban	1708	38.1 (35.6, 40.6)
Education level		
<12 years of formal education	2606	58.1 (55.7, 60.4)
≥12 years of formal education	1877	41.9 (39.5, 44.3)
Wealth band		
Poorest	848	18.9 (17.4, 20.5)
Second	937	20.9 (19.3, 22.6)
Middle	818	18.3 (16.8, 19.8)
Fourth	832	18.6 (16.7, 20.6)
Richest	1049	23.4 (21.0, 25.9)
Occupation		
Unemployed	1799	40.1 (37.9, 42.4)
Employed	2685	59.9 (57.6, 62.1)
CI: confidence interval		

Table 2: prevalence of various NCD risk factors across demographic and socio-economic strata, Kenya STEPS, 2015									
	Prevalence (%)								
Variable	n	Current tobacco use	Harmful alcohol use	Hypertension	Non-use of helmets	Non-use of safety belts	Central obesity	Type 2 diabetes	Multiple/≥4 NCD risk factors
Gender									
Male	1791	19.9	18.1	24.2	89.5	79.8	32.9	2.0	88.4
Female	2693	0.9	2.2	25.0	56.0	56.0	49.5	2.8	82.6
Education level									
<12 years of formal education	2606	12.1	6.3	27.3	81.7	73.9	51.5	1.4	85.4
≥12 years of formal education	1877	7.6	2.6	23.5	54.1	53.9	30.8	1.3	84.6
Residence									
Rural	2776	9.2	4.6	24.7	75.6	64.3	43.4	1.9	85.9
Urban	1708	11.8	5.0	24.9	69.0	67.4	42.0	3.4	85.0
Occupation									
Unemployed	1799	6.9	9.3	24.1	74.8	63.2	46.3	0.7	84.2
Employed	2685	12.4	1.6	25.9	72.1	67.1	40.6	1.8	86.5
Wealth band									
Poorest	848	8.9	5.9	19.4	76.1	61.4	45.5	1.6	82.2
Second	937	10.4	5.3	24.3	76.9	58.8	40.6	1.5	86.1
Middle	818	11.6	5.1	27.5	78.1	66.4	44.6	2.0	86.6
Fourth	832	12.1	4.4	24.7	66.8	69.6	39.7	3.0	89.3
Richest	1049	8.4	3.3	29.0	68.6	71.0	43.9	5.2	83.7
Age group									
18-29	2062	7.4	4.0	23.9	48.2	27.5	13.5	0.6	81.3
30-39	1045	12.6	12.0	29.3	83.7	67.6	37.3	2.3	87.5
40-49	695	12.8	12.9	21.5	97.1	92.8	62.2	5.8	91.4
50-59	443	11.6	10.4	25.7	80.8	69.8	68.2	7.4	89.4
60-69	239	13.7	16.7	31.8	85.1	56.1	70.3	6.0	90.7

Table 3: socio-demographic determinants of the main modifiable NCD risk factors, Kenya STEPS, 2015								
Predictor	Physical inactivity		Current tobacco use		Heavy episodic alcohol use		Unhealthy diets	
	aOR* (95% CI)	P-value	aOR* (95% CI)	P-value	aOR* (95% CI)	P-value	aOR* (95% CI)	P-value
Sex								
Female	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
Male	1.15 (0.86,1.53)	0.338	7.63 (5.63, 10.33)	<0.001	9.9 (5.3,18.8)	<0.001	1.33 (1.04, 1.70)	0.24
Age group								
18-29	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
30-39	1.01 (0.69,1.47)	0.964	1.76 (1.14, 2.74)	0.011	1.7 (1.1,2.7)	0.05	0.83 (0.70, 0.98)	0.030
40-49	0.54 (0.35,0.83)	0.005	1.13 (0.74, 1.72)	0.585	1.9 (1.0,3.5)	0.05	0.68 (0.56, 0.83)	<0.001
50-59	0.63 (0.47,0.89)	0.067	1.33 (0.91, 1.94)	0.137	1.2 (0.8,1.8)	0.46	0.53 (0.42, 0.67)	<0.001
60-69	0.59 (0.37,0.94)	0.027	0.81 (0.45, 1.46)	0.481	1.7 (1.0,3.0)	0.07	0.46 (0.33, 0.62)	<0.001
Residence								
Urban	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
Rural	0.66 (0.47,0.92)	0.014	0.65 (0.49, 0.86)	0.003	0.6 (0.4,1.0)	0.04	1.19 (0.89, 1.59)	0.239
Years in formal schooling								
<12 years	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
≥12 years	0.46 (0.29,0.73)	0.001	0.11 (0.07, 0.17)	<0.001	1.5 (0.8,2.8)	0.21	1.21 (0.95, 1.55)	0.120
Wealth band								
Poorest	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
Second	0.88 (0.54,1.42)	0.587	0.68 (0.45, 1.04)	0.072	0.8 (0.4,1.6)	0.45	0.8 (0.4,1.6)	0.45
Middle	1.16 (0.71,1.91)	0.549	0.58 (0.37, 0.91)	0.019	0.7 (0.4,1.5)	0.38	1.07 (0.78, 1.47)	0.38
Fourth	1.63 (0.99,2.67)	0.054	0.61 (0.38, 0.97)	0.037	0.8 (0.4,1.8)	0.64	1.75 (1.38, 2.21)	<0.001
Richest	2.42 (1.42,4.13)	0.001	0.63 (0.38, 1.06)	0.082	1.7 (0.8,3.8)	0.18	1.64 (1.26, 2.14)	<0.001
Employment status								
Unemployed	1.00 (ref)		1.00 (ref)		1.00 (ref)		1.00 (ref)	
Employed	1.32 (0.75, 2.34)	0.334	0.67 (0.52, 0.85)	0.001	0.58 (0.45, 0.76)	<0.001	0.84 (0.58, 1.21)	0.355
*aOR: adjusted odds ratio; ref: reference; CI: confidence interval								

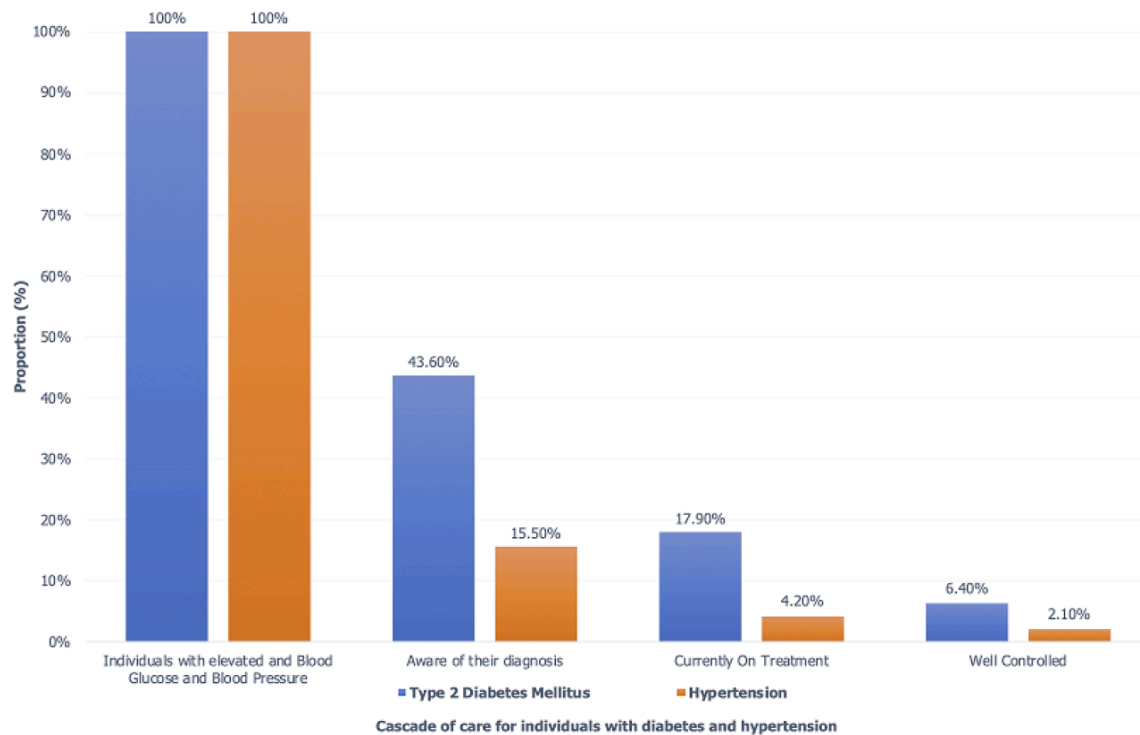





Figure 1: management cascade for type II diabetes mellitus and hypertension in Kenya from awareness to control

COMMENTARY

Recommendations for the use of mathematical modelling to support decision-making on integration of non-communicable diseases into HIV care

Joseph Kibachio^{1,2*}, Valerian Mwenda^{1*}, Oren Ombiro¹, Jamima H Kamano^{3,4}, Pablo N Perez-Guzman⁵, Kennedy K Mutai⁶, Idris Guessous⁷, David Beran⁸, Paratsu Kasaie⁹ , Brian Weir⁹, Blythe Beecroft¹⁰, Nduku Kilongo⁶, Linda Kupfer¹⁰  and Mikaela Smit^{5,9*} 

[§]**Corresponding author:** Mikaela Smit, St Mary's Campus, Imperial College London, W2 1PG, United Kingdom. Tel: +0044 20 7594 3290. (mikaela.smit@imperial.ac.uk)

*These authors have contributed equally to the work.

Abstract

Introduction: Integrating services for non-communicable diseases (NCDs) into existing primary care platforms such as HIV programmes has been recommended as a way of strengthening health systems, reducing redundancies and leveraging existing systems to rapidly scale-up underdeveloped programmes. Mathematical modelling provides a powerful tool to address questions around priorities, optimization and implementation of such programmes. In this study, we examine the case for NCD-HIV integration, use Kenya as a case-study to highlight how modelling has supported wider policy formulation and decision-making in healthcare and to collate stakeholders' recommendations on use of models for NCD-HIV integration decision-making.

Discussion: Across Africa, NCDs are increasingly posing challenges for health systems, which historically focused on the care of acute and infectious conditions. Pilot programmes using integrated care services have generated advantages for both provider and user, been cost-effective, practical and achieve rapid coverage scale-up. The shared chronic nature of NCDs and HIV means that many operational approaches and infrastructure developed for HIV programmes apply to NCDs, suggesting this to be a cost-effective and sustainable policy option for countries with large HIV programmes and small, un-resourced NCD programmes. However, the vertical nature of current disease programmes, policy financing and operations operate as barriers to NCD-HIV integration. Modelling has successfully been used to inform health decision-making across a number of disease areas and in a number of ways. Examples from Kenya include (i) estimating current and future disease burden to set priorities for public health interventions, (ii) forecasting the requisite investments by government, (iii) comparing the impact of different integration approaches, (iv) performing cost-benefit analysis for integration and (v) evaluating health system capacity needs.

Conclusions: Modelling can and should play an integral part in the decision-making processes for health in general and NCD-HIV integration specifically. It is especially useful where little data is available. The successful use of modelling to inform decision-making will depend on several factors including policy makers' comfort with and understanding of models and their uncertainties, modellers understanding of national priorities, funding opportunities and building local modelling capacity to ensure sustainability.

Keywords: policy; integration; modelling; Kenya; non-communicable diseases; HIV

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1 | INTRODUCTION

The growing burden of non-communicable diseases (NCDs) in low- and middle-income countries calls for concerted efforts at prevention, early detection and optimization of health systems for effective chronic care delivery. Given the multi-morbid nature of NCDs [1,2], it also calls for a shift from fragmented health systems to more integrated and holistic care provision [3].

One of the approaches policy makers in countries with poorly resourced NCD programmes could consider is integration of chronic care services into existing robust primary health structures. An example of where this is taking place is Kenya, whose National Strategy for Prevention and Control of NCDs 2015 to 2020 emphasizes linkage of care between major NCDs and communicable diseases such as human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) and tuberculosis (TB) [4]. Separate

care models can result in redundancies at the system, service and patient level, such as separate training programmes, laboratory infrastructure and data systems [5,6]. Integration is premised on the assumption that these redundant edges in well financed primary care platforms can be leveraged for under-resourced and under-developed programmes such as those for NCDs and that there exists potential for synergies and shared benefits for both provider and user in delivering integrated and comprehensive care packages.

However, many challenges and barriers to implementation of integrated service provision remain which necessitate evidence-based research to facilitate the translation of strategic and policy commitments to practical changes on the ground. Mathematical models have provided evidence-based guidance for decision-making around priorities, optimization and implementation of services. Although no modelling study has focused on the systematic evaluation of integration of NCD services into existing platforms, there are many examples from Kenya and the wider region of how mathematical models have supported decision-making more generally.

In this study, we examine the case for NCD-HIV integration, use Kenya as a case-study to highlight how modelling has supported wider policy formulation and decision-making in healthcare and to collate stakeholders' recommendations on use of models for NCD-HIV integration decision-making.

2 | DISCUSSION

2.1 | The burden of NCDs in sub-Saharan Africa

Across sub-Saharan Africa (SSA), NCDs are the second leading cause of morbidity and mortality after HIV/AIDS [7], yet global financing for NCDs comprises less than 2% of total health expenditure [8]. Studies from both high income countries and LMICs have shown that people living with HIV (PLHIV) experience a higher NCD burden [2,9,10]. A recent modelling study estimates that 51% of Kenyan adults currently suffer from ≥ 1 NCD, that this burden was higher in PLHIV compared to HIV negative and is projected to increase [11]. It identified hypertension, elevated total cholesterol, diabetes, chronic kidney disease and depression as the most prevalent NCDs, with cardiovascular disease and cancer as the main NCD-related causes of deaths, irrespective of HIV status [11]. While the mechanisms of NCDs in the context of HIV are not fully understood, they likely involve complex interactions between traditional risk factors, including smoking, diet, and exercise, and HIV-specific risk factors, including long-term immune activation, inflammation and toxicity related to long-term ART use [2].

Every country in the region will have outlined their priorities for NCDs in their national strategic plan. In Kenya, the National Strategy for Prevention and Control of NCDs 2015 to 2020 lays emphasis on four major NCDs: cardiovascular conditions, cancers, diabetes, and chronic obstructive pulmonary diseases and their shared risk factors [4]. The Kenyan Poverty Commission found that NCDs decrease household income by an estimated 29% and can subject families to catastrophic expenditures and poverty [12]. This threatens the achievement of Universal Health Coverage (UHC) aspired by the region, as one of the pillars of UHC is to cushion

individuals, households and communities from catastrophic and impoverishing health expenditures [13].

2.2 | The case for integrated care

Integration of health services is the foundation of primary healthcare and will form the foundation of UHC [14]. Integration has been shown to generate advantages for both provider and user, and has been demonstrated to be cost-effective, practical and rapidly scalable [15-17]. For the users, integration can increase equity, decrease stigma associated with healthcare demand, improve access to services and disease outcomes [18]. For example, The Integrated Management of Childhood Illness initiative uses a comprehensive primary care-based service delivery model to reduce both morbidity and mortality and promote improved health childhood development [19]. From the supply side, integration can generate economies of scope and reduce redundancies in resource limited settings [14]. For example, leveraging existing infrastructure such as buildings, laboratory and supply chains can generate economic savings while joint supervision, training and mentorship has been shown to reduce demand on health workers' time [14].

2.3 | Forms of integration

Integration may take various forms [14,20], with many approaches already successfully operating in SSA. In Kenya, integration to date is mainly in the areas of infectious disease and maternal and child health. Integration can focus on providing a package of preventive and curative health interventions for a particular population group, such as the "Integrated Management of Childhood Illnesses" programme. Similarly, integration can involve offering multiple services for diseases requiring common interventions under "one roof," such as integrating nutritional services in Diabetes Centers of Excellence which include integration of laboratory and supply chains. Finally, integration at the policy level can include jointly agreed health sector strategies, joint health sector performance reviews and sector-wide approaches.

2.4 | HIV as an example of integrated care

The HIV response provides, perhaps, the best example of how integration can be successfully operationalized for chronic conditions. Despite being an infectious disease, care for HIV has evolved into a chronic care model, that involves patient follow-up, continuity of care, monitoring and auxiliary services to maintain patients' health and quality of life. HIV/AIDS prevention and treatment services have been successfully integrated with services focused on maternal and child health, TB, nutritional advice, family planning services, lifestyle advice services and screening programmes for NCDs [21-23], and has established strong health systems, financing and infrastructure across many LMIC settings.

2.5 | The case for NCD-HIV integration

It is clear, given the large and growing burden of NCDs in both PLHIV and the general population across SSA, that services for the screening and treatment of NCDs will play an

important role in the preservation of health. Building on HIV platforms could shorten the learning curve for NCD prevention and control [24–27], particularly for countries with large HIV programmes and small, un-resourced NCD programmes. Considering their shared chronic nature, a majority of the programmatic and operational approaches and infrastructure developed for HIV programmes could be used for NCDs, especially in resource-constrained settings [18]. For instance, the surveillance systems that have been used in the HIV response can be leveraged to quantify the magnitude of NCDs, the cost of prevention and management, identify vulnerable population groups and assess the effects of policy and operational interventions [24]. Other potential areas of integration for NCDs include peer support, m-Health and community-based screening [17]. In fact in Uganda leveraging the HIV prevention and care infrastructure to deliver multi-disease services (hypertension and diabetes) resulted in marginal incremental cost of integrating screening for these NCDs compared with the cost of HIV testing [28].

Despite the numerous merits of NCD-HIV integration, concerns remain, including that integration may compromise existing successes and reverse HIV advances that have been achieved. There are concerns around (i) inequity in NCD care provision in early phases of implementation, with more NCD care for PLHIV than the general population, (ii) how service provision designed for low-prevalence diseases could be scaled up rapidly enough to deal with highly prevalence NCDs such as hypertension and (iii) how individual and environmental barriers to NCD care seeking behaviour can be overcome [29]. Other challenges to providing fully funded programmes at no or low cost to patients include the need for significant upfront investments, provider training and set up of robust supply chains. This is further compounded by the exclusivity that characterizes current vertical disease programming, policy, financing and operations. Finally, NCDs are complex and attract low financing, while an expectation of free services and medications was created by HIV care.

In this era of UHC and with the push towards more domestic financing, the potential benefits seem to outweigh the risks of integration, however, by providing opportunities to strengthen the health system at large. Nevertheless, each disease entity within NCDs has its unique challenges, and these should be considered when planning for integration. As Kenya and other countries around the region focus on rolling-out integrated NCD-HIV programmes, they will need to be guided by robust evidence around priorities, optimization and implementation of these programmes in order to both ensure return on investment and safe-guarding of existing programmes.

2.6 | Why mathematical modelling?

Mathematical modelling provides a powerful synthesizing tool, with multiple applications in the health sector and policy development. Although to date no modelling study has focused on systematic evaluation of integration of NCD services into existing platforms, there are many examples of how mathematical models have supported decision-making, particularly in the field of infectious diseases and HIV. In this section, we use Kenya as a case-study to highlight how modelling has supported wider policy formulation and decision-making in

healthcare and later collate stakeholders' recommendations on use of models for NCD-HIV integration decision-making. While we focus on Kenya as a case study, the lessons, priorities and recommendations identified will apply to other LMICs with large HIV and un-resources NCD programmes and to the use of modelling in decision-making more widely.

2.7 | The role of mathematical models in estimating disease burden

Estimates of disease burden, as well as projections of how these may change over time are crucial to inform strategic planning of health services in the country, yet surveillance systems in many LMIC countries still focus on capturing data on only a handful of key areas, such as infectious diseases, child and maternal health and death registries. Accurate NCD data for policy utility has been a major bottleneck in all SSA due to the lack of surveillance systems for these diseases. Data on NCDs in many countries, including Kenya largely derived from the WHO Stepwise Survey [30] or geographically limited, usually pilot, research studies. Kenya is in the process of strengthening NCD indicators in the national health information systems to provide routine reliable data to inform planning. To bridge the current data gap, mathematical modelling utilizing multiple data sources to extrapolate NCD outcomes provides an opportunity to improve the availability and accuracy of locally relevant data for policy and programming.

There are many examples of how mathematical models have been used to establish the burden of individual infectious diseases and generate risk maps, for example HIV, TB and malaria at national or sub-national levels across SSA [31–34] and have long been used to generate annual HIV estimates that aid in planning and resource mobilization in Kenya. However, few models have established the burden of multimorbidity of NCDs [11,35–38]. In 2019, modelling was used to provide the first-ever national estimates of six NCDs and eight cancers by HIV status in Kenya, by combining a data landscaping exercise of available NCD data, and triangulating it with demographic data in a modelling framework [11]. The results will be summarized in the first ever national report on NCD estimates in 2020 and will help inform priorities around integrated NCD-HIV activities.

2.8 | The role of modelling in optimizing healthcare provision

Within the realms of health system optimization, models have been used to identify health care priorities, including systematic comparison of prevention measures, and evaluations of the cost-effectiveness of integrating health services [39–43]. Many of these findings have fed directly into national and global policy. For example, the 2014/2015 to 2018/2019 Kenya AIDS Strategic framework includes recommendations informed by a modelling exercise [40,44]. This model analysis found that selectively targeting primary HIV prevention interventions to population and regions at highest risk of HIV could achieve a 55% reduction in new HIV cases by 2030, compared to 40% when interventions were adopted uniformly across the country [40]. More recently, the World Health Organization launched its global strategy for cervical cancer

Table 1. Summary of priority research questions on the pathway to integration as collated through consultation with key stakeholders

1. What is the impact of integration on improving access to primary prevention services?
2. What is the optimal entry-points for integration (e.g. HIV platforms, child health to deliver health services to siblings and mothers)?
3. What risk does integration pose at jeopardizing the gains made in the primary platform, for example, HIV programme?
4. Are there economies of scope relating to integration of individual services?
5. How does regional disease prevalence affect the cost-effectiveness of integration?
6. What is the impact of reducing or removing user fees on cost-effectiveness of integration/what are the optimal user fees contribute for services under UHC?
7. Within which laboratory sample transport system should NCD diagnostic samples be integrated?
8. What components have the greatest impact when integrated along the continuum of care and what are the markers of success?

HIV, human immunodeficiency virus; NCDs, Non-communicable diseases; UHC, Universal Health Coverage.

elimination, which was informed by an extensive modelling consultation [41].

2.9 | The role of mathematical modelling in exploring health system capacity needs

Finally, models have also been used to explore questions around task-shifting, human resources needs, and optimization of health financing mechanisms [45–48]. In Kenya, one study looked at long-term economic impact of return on investment and found that shifting cognitive behavioural therapy to reduce alcohol abuse among PLHIV to paraprofessionals is effective and economical and averts alcohol-related morbidity and mortality [45]. Another study evaluated optimal financial mechanisms to sustain UHC in Kenya, including social health insurance and general tax-funding mechanisms [46]. The study provided recommendations for long-term financial sustainability, which included a tax-funding system and innovative financing options [46].

2.10 | Recommendations for the use of mathematical modelling to support NCD-HIV integration

NCD-HIV integration appears to be a cost-effective and sustainable policy option for countries with large HIV programmes and small, un-resourced NCD programmes to rapidly scale-up their NCD programmes, and has been fully adopted by the Kenya's National Strategy for Prevention and Control

of NCDs 2015 to 2020 [4]. Yet several key policy level research gaps for NCD-HIV integration remain to be addressed, to ensure these programmes are successful. Modelling has proven to be a powerful tool to support decision-making. We carried out stakeholder consultation and collation of targeted expert opinions. This was done in a snow balling activity between June and September 2019, and included modellers from several international institutions who have supported evidence generation for policy, funders who have worked on the interface between research and policy and policy makers in Kenya from across the Divisions of Cancers, NCDs, HIV and the strategic team at the Ministry of Health. The focus of this consultation was to (i) define key questions around NCD-HIV integration, (ii) identify where and how to integrate modelling within the policy making process, (iii) identify pre-requisites for the successful use of models in policy formulation and decision-making.

The consultation highlighted eight key priority research question questions from national stakeholders, which can be addressed by modelling (Table 1). Within the well-defined steps of policy and decision making for health, we suggest that modelling methodology is likely to provide a critical entry point for enhancing these integration efforts in various ways. Policy formulation is driven by the need to provide alternative strategies or guidance for a given gap in health provision and is supported by a formal evaluation process (Figure 1). Modelling can be an important tool in the evaluation process, particularly in areas where little data exist or data collection is weak or unfeasible (Figure 1). The consultation highlighted that the use of modelling for policy formulation and decision making should be accompanied by defined processes, including formal integration into the decision-making process, robust technical review and dissemination (Figure 1 and Table 1).

Several prerequisites were identified through the consultation, for modelling to drive the integration agenda in a sustainable manner (Table 2). First, it emphasized that in order to successfully use modelling to support decision-making, the application of the models will need to be aligned with the current national aspiration and their use will need to gain wider acceptance as well as the backing of policy makers. Second, policymakers need to be sensitized on the role of modelling in public health, its approaches and techniques, assumptions and limitations. A strong and honest collaboration between modellers and policy makers is crucial to harness the potential for modelling in enhancing the integration agenda. Third, results from models should be widely disseminated, processes evaluated and validated. Models should, as with laboratory experiments, be sufficiently transparent that their results can be replicated. Fourth, models should be linked to existing surveillance and national health information systems, to ensure models serve a complementing, not a duplicating or replacing function. A case example in Kenya is in HIV surveillance system, whereby routine reporting and periodic surveys is combined with modelling to provide up-to-date information continuously.

Finally, application of modelling in public health planning and policy formulation must be conducted in a sustainable manner and include human resource capacity for modelling. Several approaches can be utilized for this purpose: availing of resources to institutionalize, maintain and sustain mathematical models to enhance visibility on their role, foster

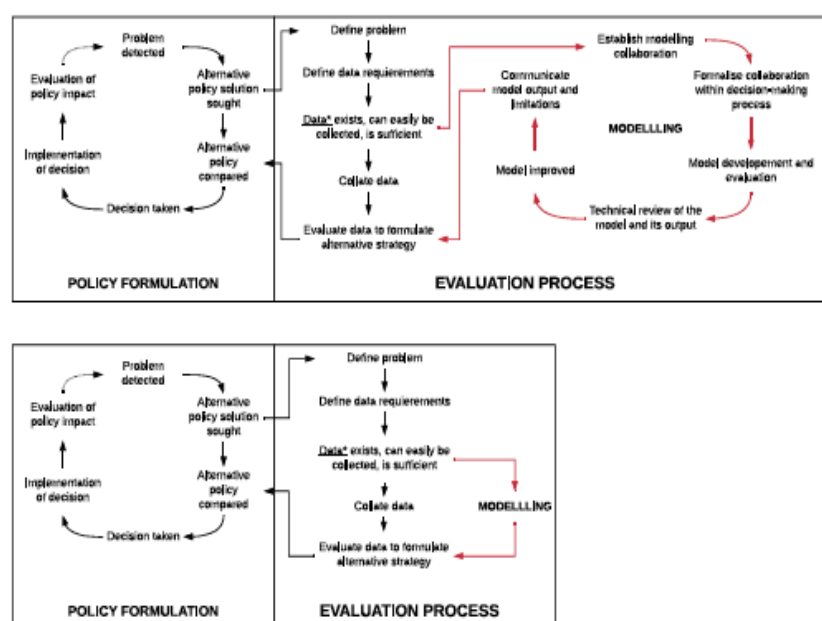


Figure 1. The role of mathematical modelling to inform policy decisions on integrated care for multi-morbidity in Kenya. *Data referring to primary or programmatic data and expert opinions.

collaboration among institutions that routinely utilize modelling to enhance partnerships and knowledge transfer and incorporating modelling in local public health training to increase the skill pool and create a critical mass of modellers. A critical bottleneck remains the sustainability of these efforts. Modelling to inform policy frequently involves collaborations

between academic institutions, which generally house modelling capacity, and governmental organizations. Academic groups rely on funding through outside sources, with funding schemes often being project specific and time limited. Altogether this means that collaborations between modellers and governments can suffer from a lack of sustainable funding. Additional funding focused on support for capacity building of in-country modellers and support for the transfer of models to countries will help ensure sustainability and continuity of efforts.

Table 2. Key stakeholder recommendations to formally and sustainably integrate modelling in policy formulation and decision-making

1. Align modelling with current national priorities
2. Sensitize policy makers to the role of modelling in policy formulation and decision-making
3. Ensure wider acceptance as well as the backing of policy makers for modelling
4. Develop a set of guidelines to evaluate the transparency, robustness and replicability of models
5. Develop a formal review of model design and output by a national technical team trained in modelling
6. Disseminate results from any policy/modelling exercise and highlight the model's limitations
7. Link models to the formal national health information systems to avoid duplication and increase efficiencies
8. Foster collaboration with established institutions that routinely utilize models to ensure knowledge transfer
9. Incorporate modelling in public health training in local institutions to build modelling capacity
10. Identify national resources to support sustainability and institutionalization of mathematical modelling

3 | CONCLUSIONS

It seems clear that mathematical modelling can and should play a central role in future policy formulation and decision-making as the sub-Saharan region grapples with questions of integration and focuses on rolling out UHC, particularly given the often limited evidenced-based data to support decisions. Models have played a central role in informing policy in other disease areas, demonstrating that they can provide a strong platform of credible research. They will undoubtedly be able to generate valuable and robust evidence to answer some key questions that remain regarding NCD-HIV integration in the region (Table 1).

First, by estimating burden, modelling can support decision-makers in setting priorities for public health policy interventions. This is key for health conditions with inadequate or weak surveillance systems and therefore little data for decision-making, of which NCDs are a good example. Second, if policy formulation or revision is required, modelling can be utilized for the formulation of optimized options for an integration approach, cost-benefit analysis for integration as well as evaluating the impact of integration of services. Finally, models can be utilized in conducting projections of future

trends of various health conditions and aid in forecasting the requisite government investments to address them effectively. This is particularly vital for SSA as the triple burden of disease phenomenon manifests in the setting of dwindling donor support. For instance, with integration, there is likely to be increased workload for human resources, and the need for additional equipment and commodities and/or. Thorough forecasting will forestall shortages of commodities and/or waste of resources as the models may provide indicative trends.

Integration of health services will require a policy backing for wide acceptability and sustainability beyond specific programmes. In addition, the change in the system of service delivery towards integration will require the interplay of political, technical and administrative action at several levels, including sustained commitment from the government, and the bridging of critical knowledge gaps. Within the well-defined steps of policymaking for health, we suggest that modelling methodology is likely to provide a critical entry point for enhancing these integration efforts (Figure 1).

Both integration and modelling ought to be aligned with the current national health priorities to gain wide acceptance and backing. A good example is putting all these efforts in the context of expansion of primary healthcare and national rollout of UHC. While encouraging the use of mathematical models, it is critical to emphasize that they are not a replacement of empirical data collection but rather a tool to assist in interpretation of this data to a more useful form.

Successful use of modelling to inform policy and decision-making will depend on several factors (Table 2) including policy makers' comfort with and understanding of models and their uncertainties, modellers understanding the policy questions, funding opportunities and building local modelling capacity to ensure sustainability. While we focus on Kenya and NCD-HIV integration as a case in point, recommendations also apply to other settings and the use of modelling in policy formulation and decision-making more widely.

It is clear that modelling has played a valuable role in the formulation of policy recommendations and decision-making across a number of disease areas and in a number of settings to date. As the paucity of NCD data for policy use in Kenya and the wider region continues to hamper policy decisions on integration, mathematical modelling should play an integral part in bridging this gap now and in the future. This paper outlines a set of clear recommendations on how to sustainably integrate modelling into decision making.

AUTHORS' AFFILIATIONS

¹Division of Non-communicable Diseases, Ministry of Health, Kenya; ²Faculty of Medicine, University of Geneva, Switzerland/Geneva; ³Department of Medicine, Moi University School of Medicine, Kenya/Eldoret; ⁴AMPATH, Kenya/London; ⁵MRC Centre for Global Infectious Disease Analysis, Department of Infectious Disease Epidemiology, Imperial College London, London, United Kingdom; ⁶National AIDS Control Council, Kenya/London; ⁷Division of Primary Care Medicine, Geneva University Hospital and University of Geneva, Geneva, Switzerland; ⁸Division of Tropical and Humanitarian Medicine, University of Geneva and Geneva University Hospitals, Geneva, Switzerland; ⁹John Hopkins Bloomberg School of Public Health, Baltimore, MD, USA; ¹⁰Fogarty International Center, National Institutes of Health, Bethesda, MD, USA

COMPETING INTERESTS

All authors report no conflicts of interest.

AUTHORS' CONTRIBUTIONS

MS, JK and LK conceived the paper, formulated the overall aim, scope and lens of the manuscript, with all authors contributing to finalizing its outline and scope. MS, VM, JK, OO and PNPG wrote the first draft of the manuscript. MS, JK, VM, OO, BB, BW, LK and PKS led the design and development of all infographics. JK, VM, OO, JHK, MKK and NK led all aspects of the policy landscape and research gaps in Kenya. MS, PNPG, BW and PKS led all model-related aspects of the manuscript. All authors contributed to the re-drafting of the manuscript and in the process of approving the final draft.

ABBREVIATIONS

AIDS, Acquired Immune Deficiency Syndrome; HIV, Human Immunodeficiency virus; NCDs, Non-communicable diseases; PLHIV, People Living with HIV; SSA, Sub-Saharan Africa; TB, tuberculosis; UHC, Universal Health Coverage.

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CHAPTER 4: CONCLUSIONS AND PERSPECTIVES

This work demonstrated important points of divergence that have a bearing on the efforts to halt and reverse the burden of NCDs within the UHC context in Kenya. While the country is grappling with a double burden of infectious diseases and non-communicable diseases, injuries are emerging as a huge burden that is clawing on the gains the country made in the MDG era. While broadly correct in attributing the exponential rise of chronic non-communicable diseases to rapid urbanization, globalization of unhealthy lifestyles and population ageing, this policy view needs to be put in context in countries like Kenya as underlying determinants like poverty, gender, level of education and other social economic constructs shape both the causation and outcome and necessitate a policy reorientation towards a more wholistic approach to NCDs.

4.1 The high burden of NCDs in Kenya and the relationship with social economic status.

The burden of NCD conditions is very diverse in Kenya and the majority of NCD DALYs when aggregated are mostly due to conditions other than the four emphasized in global monitoring frameworks. Of all the DALYs from NCDs, 67% were related to conditions other than cardiovascular disease, diabetes, neoplasms, and chronic respiratory diseases. These range from mental, neurological and substance use disorders, cirrhosis and other liver diseases, urogenital, blood and other endocrine disorders, digestive, genetic, surgical, and degenerative conditions. This is notably higher than in high-income countries, where 53% of NCD DALYs are due to conditions other than these four disease areas (30).

Majority of Kenyan adults possess more than four modifiable NCD risk factors (58), a clear indication of an emerging epidemic of NCDs in this population. While behavioural risk factors have a large attributable risk for NCDs and continue to be the backbone of the Ministry of Health's response to NCDs, using existing data sources these findings show that 73% of all NCD DALYs in Kenya are poorly attributed to individual lifestyle choices and that poverty is a major driver both in the causation and outcome of these diseases in the country.

This aligns with the complex interplay of economic, demographic, and epidemiologic changes associated with large shifts in dietary and physical activity patterns described as the nutrition transition, which has been proposed as a primary driver of the alarming rise in obesity, diabetes and other NCDs in LMICs (59). Within this framework, and the recently proposed obesity transition theory (60), unhealthy lifestyle behaviours are first adopted by more affluent groups. As public knowledge of disease prevention and access to preventive services increase, social norms change, and the rise of obesity and diabetes in affluent groups is attenuated and the burden shifts to more poorer and vulnerable segments of the population (60, 61). As such, an understanding of the relationship between Social economic status and the NCDs risk in the context of a dynamic socioeconomic gradient can help identify those at highest risk of diabetes and other NCDs and guide policies to prevent, diagnose, and treat these diseases.

As an example of this concern is the high and rising prevalence of hypertension and its complications in Kenya. This observation was consistent with other lower middle income countries going by the comparison of STEPS data from 44 low-income and middle-income countries that collated nationally representative individual-level data from 1.1 million adults (62). While intra-country variations exist, cascades of treatment in this study were consistent with those from this huge, pooled data set. Among those with hypertension, 73.6% had ever had their blood pressure measured, 39.2% had been diagnosed with hypertension, 29.9% received treatment but only 10.3% achieved control of their hypertension (62). This may be attributed to low levels of awareness, poor health systems with weak screening and early detection components as well as poor access to treatment. This fragile state of health systems is worse within the public health sector and more pronounced in the rural setting where the most indigent and poor communities reside.

Of note too is that in terms of mortality, NCDs are responsible for 35% of all deaths in Kenya with 22% of these occurring before the age of 40 (30). This calls for effective and multi-sectoral interventions targeting multiple risk factors at both the individuals and systemic level to be deployed across the life course and not only targeting the older populations. This will need to be put in the broader context within which they exist as demonstrated here that social economic status has a huge effect on both causation and control of these conditions.

As the Universal Health Coverage is being rolled out in the country (63), (64), (65), these findings are being used to advocate for a more elaborate investment in NCDs considering the potential of these diseases in spiralling individuals, families and communities into poverty owing to the rising incidence and the high and catastrophic costs associated with their control.

4.2 The disproportionate economic impact of NCDs on households

It is well documented that vulnerable and socially disadvantaged people get sicker and die sooner than people of higher social positions, especially because they are at greater risk of being exposed to harmful products, such as tobacco, or unhealthy dietary practices, and have limited access to health services (66). In low-resource settings, health-care costs for NCDs quickly drain household resources. The exorbitant costs of NCDs, including treatment, which is often lengthy and expensive, combined with loss of income, force millions of people into poverty annually and stifle development. In line with our findings, the economic impact of NCDs on households is not only due to the household spending on NCDs but also due to loss of productivity.

Data from the Kenya Household Health Expenditure and Utilization Survey (67) showed that although general health conditions reduce household income by 13.6%, NCDs reduce household income by 28.6%. Furthermore, NCDs were associated with a 23.2% reduction in household income relative to households affected by communicable diseases (68). Overall, for households experiencing NCDs, 29.9% of those in the lowest quintile experienced catastrophic expenditures (defined as >30% of total household income), compared to 9.2% in the highest income quintile. The rate of catastrophic expenditure was higher for rural (20.8%) as compared to urban (13.6%) households (69). It was noted that the odds of incurring catastrophic expenditure for households were over 50% higher for those affected by NCDs as compared to households affected by communicable diseases. Furthermore, the odds of becoming impoverished due to out-of-pocket expenditures for a household were over 30% higher for those affected by NCDs as compared to households affected by communicable diseases (69).

As per the Kenya National Health Account (NHA) (54), a huge proportion of NCD financing is from government sources, employers and out of pocket from families with the bulk of it being spent in government health facilities mostly for outpatient curative

care services. This represents approximately \$4.48 USD per capita. Despite a rise in the episodes of injuries, there was a 4.1 % decrease in the expenditure on injuries (54). This study demonstrated that the domestic financing for NCDs was very limited and not commensurate to the burden (30). The expenditure on NCDs in fiscal year 2015/16 was \$198,568,740 USD, or 5.7% of Total Health Expenditure (THE)(\$4.48 USD per capita), a decrease from 6.2% in FY 2012/13. This figure is way below the \$11.76 per capita annual incremental investment modelled and recommended by the NCDI poverty commission to launch and or scale up the package of interventions envisaged to halt and reverse the NCDI burden in Kenya to achieve an approximate 10% reduction in premature mortality by the year 2030 (30). This package of interventions, which includes outpatient, inpatient, surgical, mental health, rehabilitation, and palliative care services have been recommended and are part of the revised National NCD and injuries prevention and control strategy draft.

These findings when modelled with data on the increasing incidence of NCDs make a case for inclusion of NCD prevention and control in the comprehensive UHC package to shield individuals and families from the catastrophic costs associated with a member being diagnosed with an NCDI. As the majority of Kenyans don't have comprehensive health insurance (63), a diagnosis of an NCD is catastrophic as much of the treatment will need to be catered for from out of pocket sources. Mitigating the impoverishing effects of NCDs will require the expanded coverage of the national social insurance program, establishment and strengthening of social safety nets for the poor, and increased focus on more equitable access to both preventive and curative health services through coherent cross-sectoral policies and plans. There is need to expand investment in the NCDI response via increases in direct domestic financing through capitation, insurance revenues, and innovative financing mechanisms and partnerships (30).

4.3 The skewed standards of health and services availability for NCDs in Kenya

This study intended to understand the system readiness, availability and coverage of NCD and injuries services in the Kenyan health sector and the effectiveness of the current approach towards halting and reversing the NCD burden in Kenya in the context of UHC. The revised Kenya Essential Package for Health (KEPH) plan in the Kenya Health Sector Strategic Plan (HSSP) describes the specific services to be provided

by the various tiers of the health system for the separate age cohorts in different tiers of care (community level, primary care level, county level, national referral level). Services are arranged from simple health promotion and education at the community and institutional screening at the primary level; to the more complex diagnosis and treatment at tertiary referral facilities (67).

The Kenya National Essential Medicines List (NEML)(53) details the medications to be available at the various levels of public health sector facilities. The list was revised in 2016 by the National Medicines and Therapeutics Committee, updating the previous list developed in 2010 by convening national and local experts and incorporating normative guidance from the WHO.

While Kenya may be relatively better stocked than some same level nations, a comparative analysis using the previous NEML showed that among 10 African countries (Egypt, Eritrea, Ethiopia, Kenya, Lesotho, Seychelles, Somalia, Tanzania, Togo and Uganda), Kenya had an approximately average number of total medications and was missing 30% of the medications from the WHO Essential Medicines List, less than the average of 42% of the 10 countries (70).

Using the most recent nationally representative comprehensive health facility survey conducted in the country; Service Availability and Readiness Assessment Mapping (SARA) in 2013 (52), the study measured the reported service provision and observed availability of key personnel, guidelines, equipment, diagnostics and medications for several NCDI conditions, including cardiovascular disease, diabetes, and chronic respiratory diseases.

With only a third of the health facilities surveyed considered ready for NCD services as measured by the presence of standard precautions, basic amenities, basic equipment and essential medicines, it was concerning that only one in 20 of the sampled facilities had all components available. Compared to other disease areas, essential NCD medications were less available at both hospitals (32%) and primary care facilities (25%) than medications for malaria (65% and 55%, respectively), tuberculosis (TB) (55% and 51%, respectively), and HIV (35% and 47%, respectively) (52).

The distribution of NCDI referral services listed in the Kenya Essential Package for Health (KEPH) and specialty physicians availability throughout the country has not been

well quantified, though such resources are limited and largely concentrated in urban areas making access to the poor rural folk difficult. On correlating availability with ability to pay, regions with a higher proportion of the population living in the poorest billion had a lower mean number of tracer NCD medications available as compared to regions with a lower proportion of population living in the poorest billion.

The Kenyan Universal Health Coverage monitoring framework adopted from the World Health Organization UHC monitoring Framework suggests key indicators for NCDs should include population coverage of hypertension and diabetes as a marker. It is however difficult to ensure guaranteed access to care as per need considering the skewed and inequitable distribution of medication as well as expertise along the entire continuum of care. Despite the Kenyan National Strategy for the Prevention and Control of NCDs 2015–2020 going beyond the WHO Global Action Plan framework to include additional conditions, such as violence and injuries, palliative care, mental disorders, cognitive impairment, renal disorders, hepatic disorders, endocrine disorders, neurological conditions, hemoglobinopathies, gastroenterological, musculoskeletal, skin disorders, oral diseases, disabilities including visual and hearing impairment, and genetic disorders ([71](#)), this work found that availability of key medications and readiness of NCD services remains limited and inversely related to the poverty level of regions.

Of particular note is the skewed coverage of NCDI services like the distribution of cancer screening that suggested a socioeconomic trend. In the Kenya DHS 2014, cancer screening was higher among those in the wealthiest quintile as compared to those in the poorest quintile for breast cancer (22.7% vs. 4.4%, respectively), cervical cancer (22.9% vs. 4.4%), and prostate cancer (3.9% vs. 1.5%). Screening for each of the above cancers was also found to be higher in urban compared to the rural areas ([50](#)). With such skewed coverage, it is difficult then to guarantee the one-third reduction in pre-mature mortality from non-communicable diseases (NCDs) by 2030 through prevention and treatment, and promote mental health and wellbeing as envisioned in SDG 3.4 ([25](#)).

The same trend was noted and consistent when the lifetime prevalence of Cervical Cancer Screening in 55 Low- and Middle-Income Countries was evaluated. There was a large variation in the self-reported lifetime prevalence of cervical cancer screening among countries within regions and among countries with similar levels of per capita

gross domestic product and total health expenditure. Within countries, women who lived in rural areas, had low educational attainment, or had low household wealth were generally least likely to self-report ever having been screened (72). This pattern of access across the African region may contribute to most NCDs being detected at an advanced stage where long term complications have set in, treatment is expensive and complex and the outcome is poor.

Despite the recent attention and prominence in rights-based approaches to health, and addition of mental health to the WHO 5 by 5 monitoring matrix, mental health disorders are a commonly unrecognized burden of NCDs in Kenya despite comprising 4.6% of all DALYs (GBD, 2016). A population-based household survey in Nyanza Province reported a rate of common mental disorders of 10.8%, comprising of mixed anxiety/depression (6.1%), panic disorder (2.6%), generalized anxiety disorder (1.6%), and depressive episodes (0.7%)(73). One or more psychotic symptoms were reported in 13.9% of the population, with a significantly higher prevalence in women (17.8%) than men (10.6%) (74) and SES significantly inversely associated with prevalence of common mental disorders, with the lowest asset group 2.5 times more likely to suffer from common mental disorders than the highest asset group (75).

In view of the skewed standards of health and service Availability for NCDIs in Kenya there is need for greater governmental and non-governmental efforts towards protecting the poor from catastrophic illness cost burdens. (76). Promising health sector options to level the access field include the elimination of user fees to enable most people especially the indigent access care in a timely fashion, developing and sustaining more flexible and equitable social insurance schemes, and improving quality of care in all facilities. In this regard, multi-sectoral approaches with interventions beyond the health sector to alleviate poverty and cushion poor households from catastrophic health costs are key (76).

4.4 The Need for reframing NCDIs for equity within the Universal Health Coverage context and the suggested policy interventions.

The objective of the Kenya NCDI Poverty Commission was to recommend a package of cost-effective health sector interventions that could be implemented in Kenya to halt and reverse the NCDI burden.

The Commission undertook a process to prioritize among NCDs conditions for the Kenya health sector based on principles of priority setting established by the WHO Consultative Group on Equity and Universal Health Coverage (UHC) (55). The study group adopted an emphasis on conditions based on the overall health impact of each condition (“burden of disease”), the severity of the condition in terms of premature mortality (“severity”), the extent of disability caused by the condition on each individual affected (“disability”), the inequity of health outcomes from the condition as compared to other regions of the world (“equity”) and national diseases/conditions priorities (30). The commissioners then selected a final set of 14 conditions based on their ability to contribute significantly to adverse health and economic consequences in Kenya, how feasible and effectively they can be controlled in Kenya, and their being complementary to ongoing strategy and efforts by the Government of Kenya (GoK) as per the national health policy and NCD strategic plan.

The 14 conditions selected were recommended to build on the existing Kenya NCD Strategic Plan and UHC rollout and include asthma, chronic obstructive pulmonary disease (COPD), hypertensive heart disease and stroke, rheumatic heart disease, diabetes (type 1 and 2), cervical cancer, non-Hodgkin lymphoma, breast cancer, major depressive disorders, epilepsy, sickle cell disease, cirrhosis, motor vehicle road injuries, and interpersonal violence/assault (30). Alongside the 14 focus conditions, the study group recommended a package of thirty-four interventions to be introduced or intensified within the health sector. These interventions were selected on the criteria of potential health impact, cost-effectiveness, financial risk protection, and priority to the “worst-off”, including those that could avert more severe or premature complications. With implementation of these interventions, it was estimated that over 9322 premature deaths can be averted annually by the year 2030. These interventions, span across outpatient, inpatient, surgical, mental health, rehabilitation, and palliative care service. At the population and community level, prioritized interventions based on cost-effectiveness, financial risk protection, equity, and alignment with prioritized NCDI conditions would include mass media messaging on awareness of handwashing and household air pollution, tobacco and alcohol, healthy eating and physical activity. Suggested too for introduction and or scale up were targeted education of diabetes on self-management, tobacco cessation counselling, nicotine replacement therapy, school-

based HPV vaccination for girls as well as the use of community health workers to screen for cardiovascular risk factors to facilitate referral of patients for medical management and improve adherence to cardiovascular interventions.

The majority of interventions selected for introduction or scale up would be applied at the primary care or health centre level. These interventions include outpatient medical management and chronic follow up of asthma/COPD, cardiovascular disease, chronic heart failure, diabetes, epilepsy, depression/ anxiety, and schizophrenia. Health centre level interventions to scale would also include screening for hypertension in all adults and diabetes in high-risk adults as well as screening and management of hypertension and diabetes in pregnancy. Primary and secondary prevention of rheumatic heart disease was emphasized at primary health centres. Additionally, opportunistic screening for cervical cancer using visual inspection (acetone or Lugol's iodine) or HPV DNA testing and cryotherapy for small precancerous lesions was included at this level. This would foster early detection and control that would effectively improve the treatment outcome and prognosis.

At the county hospital level, strengthening and scaling up of inpatient management of acute exacerbations of asthma/ COPD and heart failure as well as the treatment of early-stage cervical cancer within existing services was suggested for prioritization. Additionally, the introduction and scale up of medical management for sickle cell disorder was chosen to be included owing to its growing burden in some regions of the country. Multimodal breast cancer treatment and treatment for childhood cancers (i.e. leukaemia and lymphoma) were prioritized at the referral hospital level. Also Included in the priority interventions are cross-cutting packages to improve basic and county-level surgical and laboratory services, rehabilitation, and palliative care services (30).

4.5 Projected incremental cost and return on investment

Along with facility and central-level indirect costs, the total annual cost the incremental increase in coverage represented by this package is estimated to be \$520,146,154 USD, or approximately 54.7 billion Kenyan Shillings. Although this package of interventions would represent a 2.6-fold increase in the current expenditure on NCD services as detailed in the national health accounts 2015/16, it would represent only 17.1% of total health expenditure. Overall, this package of interventions, which includes outpatient, inpatient, surgical, mental health, rehabilitation, and palliative care services would

represent an incremental investment of \$11.97 per capita annually. The majority of interventions selected for introduction or scale up would be applied at the primary care or health centre level and would include infrastructure, staffing, training, guidelines, medications, equipment, diagnostics, and strengthening of referral networks.

As most of these interventions exist at some baseline level in public health sector facilities albeit with varying availability and readiness, these interventions, if implemented to target coverage, are projected to avert 9,322 premature deaths per year by the year 2030 which represents an approximate 10% reduction in expected premature deaths in the year 2030 (according to 2015 death rates) ([30](#)).

4.6 Integrating NCD prevention and control into primary health platforms like HIV, TB and Maternal Health care and the use of mathematical models to plug the data gap.

Integration and task sharing was one of the policy recommendations from the work of the Kenyan NCD and Injuries Poverty Commission noting that integration of NCD services for non-communicable diseases into existing primary care platforms such as HIV programmes is a possible avenue of strengthening health systems, reducing redundancies and leveraging existing primary care health systems to rapidly scale-up underdeveloped programmes. Given the finite resources and competing priorities for health that the Kenyan government has to deal with, leveraging existing infrastructure and personnel for other diseases, such as HIV/AIDS and TB care may facilitate task sharing and integration of NCDs, Injuries and mental health prevention and control within these existing public health infrastructure ([77](#)). The HIV response provides, perhaps, the best example of how integration can be successfully operationalized for chronic conditions. Despite being an infectious disease, care for HIV has evolved into a chronic model of care, that involves patient follow-up, continuity of care, monitoring and auxiliary services to maintain patients' health and quality of life ([44](#)). HIV/AIDS prevention and treatment services have been successfully integrated with services focused on maternal and child health, TB, nutritional advice, family planning services, lifestyle advice services and screening programmes for NCDs ([78-80](#)) and has established strong health systems, financing and infrastructure across many LMIC settings.

Integration of NCD services will thus take advantage of the learnt experiences of an efficient HIV system to aid in the scale up while benefiting from the synergies and co-

creation of benefits for the two diseases entities. This is considering that our model indicated that within the next decade, 55% of HIV negative and 69% of PLWH will be living with more than one NCD by 2035. While the demographic shift will result in an increased NCD burden over time (irrespective of HIV status), population growth will result in a sharp increase in the absolute number of adults needing services for NCD (81).

While introducing these integrated interventions may sound intuitive, some challenges are anticipated. This includes resistance to change, opposition from the funded programs who may fear that widespread integration may jeopardize gains made as well as dilute impact on their programs. Other challenges include infrastructure, staffing, training, lack of guidelines, medications, equipment, diagnostics, and referral networks.

Even as the Kenya NCD Inter-sectoral Collaborating Committee (ICC) established started implementing some of the recommendation from this work and engaging in high level multisectoral advocacy to institutionalize the recommendations, one bottle neck remained- NCD surveillance is very poor and NCD data in Kenya is quite unreliable and frustrating not to mention unusable for policy and planning.

Compared to the quality of HIV data in the country, NCDs systems have a long way to go. It is in this context that the use of mathematical modelling was suggested and commissioned to support decision-making on integration of non-communicable diseases into HIV care. Mathematical modelling can and should play an integral part in the decision-making processes for health in general and for NCD/HIV integration specifically. It is especially useful where little data is available.

The successful use of modelling to inform decision making will depend on several factors including policy makers' comfort with and understanding of models and their uncertainties, modellers understanding of national priorities, funding opportunities and building local modelling capacity to ensure sustainability (44). It seems clear that mathematical modelling can and should play a central role in future NCD policy formulation and decision making as the sub-Saharan region grapples with questions of integration and focuses on rolling out UHC, particularly given the often limited evidenced-based data to support decisions.

Models have played a central role in informing policy in other disease areas, demonstrating that they can provide a strong platform of credible research. They will undoubtedly be able to generate valuable and robust evidence to answer some key questions that remain regarding NCD-HIV integration in the region. As the paucity of NCD data for policy use in Kenya and the wider region continues to hamper policy decisions on integration, mathematical modelling should play an integral part in bridging this gap now and in the future. This work outlined a set of clear recommendations on how to sustainably integrate modelling into decision making.

4.7 Conclusion

For the ongoing UHC rollout in Kenya to achieve the desired SDG 3.4 hinged outcome of reducing premature mortality from NCDs by a third by 2030 relative to 2015 levels, and to promote mental health and wellbeing, the national government will need to heighten policy attention to NCDs and Injuries and while doing so view them from a social developmental perspective as they are intricately linked.

While behavioural risk factors have a large attributable risk for NCDs, our findings however show that most of the NCDI disease burden in Kenya are poorly attributed to individual lifestyle choices and that poverty has a huge indirect role both in the causation and outcome of these diseases in the country. In order to adequately address NCDIs in Kenya and reduce stigma associated with these diseases, policy makers must broaden their attention beyond the traditional behavioural risk factors. The government needs to embrace a more comprehensive multi-sectoral approach with inclusive interventions across the life span as this work demonstrated that opportunities for prevention and control of NCDs exist in all cohorts of the human development and not only among the older persons.

A whole of government approach will be required as some of the determinants of NCDs like poverty fall outside the direct control of the health sector. While reframing of NCDs is not a short-term process, empowering individuals, families and communities by shielding them from the catastrophic costs associated with NCDIs is a worthwhile starting point. Building on the existing Kenya NCD Strategic Plan, it is suggested to broaden the focus of NCDs to apportion more policy attention towards the suggested conditions and interventions that have a huge potential health impact, are cost effective, offer most financial risk protection, and offer priority to the “worst-off”,

including those that could avert more severe or premature complications. The interventions suggested support both primordial and primary prevention of NCDs and Injuries as well as system strengthening efforts to improve the quality and access to care, streamline referral and improve treatment outcomes.

These interventions require local adaptation and integration into existing health services, development and strengthening of human resource capacity, boosting the capacity of supply chains, and streamlining referral pathways. These findings make a case for a meaningful inclusion of NCD prevention and control in the comprehensive UHC package to shield individuals and families from the catastrophic costs associated with a diagnosis of an NCDI. As a recommendation for increasing financing for NCDs and injuries, a 2.6-fold increase in the current expenditure is suggested. This would represent a 17.1% of total health expenditure and would cover interventions ranging from outpatient, inpatient, surgical, mental health, rehabilitation, and palliative care services and represent an incremental investment of \$11.97 per capita annually that ultimately would see 9,322 premature deaths per year averted by the year 2030.

As NCD systems in the AFRO region are poorly funded, integrating elements of prevention, screening, awareness creation, linkage to care and follow up to other primary care platforms creates synergies that will improve access and improve the comprehensiveness of services offered. As much of this reframing will start happening in an environment plagued by paucity of quality NCD data for policy and planning, mathematical modelling has been suggested as an adjunct and short-term measure to plug the data gap even as the governments invest more to build robust NCDs and injuries surveillance systems. This will take advantage of the robust surveillance systems and lived experiences from the HIV, TB, Maternal health and other primary care platforms that have a fairly stable infrastructure built and strengthened over recent decades by local and foreign resources in the MDG era.

Health system interventions alone are not sufficient to prevent the risk and impact of NCDs as well as provide care for NCDs to the Kenyan community. A truly comprehensive response to NCDs in Kenya requires a whole-of-government approach. This is more so considering that the role of poverty eradication and social protection falls outside the health sector within the department of social services. Equally, a comprehensive multisectoral engagement will tap into the resources and inputs from

other sectors of government like agriculture, sports, industry, security, gender and urban planning that have a huge stake in the quest to halt and reverse the NCDI burden.

In line with these findings, a national NCD inter-sectoral coordinating mechanism was launched to foster inter-sectoral interventions and to harness the support and synergies from outside the health sector. This inter-sectoral committee is working towards broadening Kenya's attention beyond the traditional NCDI behavioural risk factors and embracing a more comprehensive approach towards NCDIs and poverty while institutionalizing equity in NCD policy and planning.

As Kenya is currently revising its NCDs and Injuries strategic plan, parts of these findings have been adopted and are guiding the restructuring of the new policy towards a more comprehensive multi-sectoral and equitable approach. This work is further being used as an advocacy tool for increased financing and a meaningful involvement of the community especially persons living with NCDs in policy and planning. Regionally, Kenya as part of the NCDI lancet poverty commission network is providing support for other African countries towards an evidence-based and locally driven processes to determine health-sector priorities relevant to NCDIs in their respective countries and in supporting policy, research and advocacy initiatives to bridge the gap for NCDIs on the path to UHC.

Much remains to be done to reframe the prevailing policy framework in order to halt and reverse the burden of NCDs and Injuries in Kenya. While more data is needed, there is enough to act.

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ANNEXES

Annex 1: KEMRI ERC approval STEPS survey _Jan 2014 SSC 2607



KENYA MEDICAL RESEARCH INSTITUTE

P.O. Box 54840-00200, NAIROBI, Kenya
Tel (254) (020) 2722541, 2713349, 0722-205901, 0733-400003; Fax: (254) (020) 2720030
E-mail: director@kemri.org info@kemri.org Website: www.kemri.org

KEMRI/RES/7/3/1

January 07, 2014

TO: **DR. JOSEPH KIBACHIO**
PRINCIPAL INVESTIGATOR

THROUGH: **DR. EVANS AMUKOYE,**
DIRECTOR, CRDR,
NAIROBI

Dear Sir,

RE: **SSC PROTOCOL NO: 2607 (RESUBMISSION): KENYA STEPS SURVEY
FOR NON-COMMUNICABLE DISEASES RISK FACTOR (STEPS V5-
3/01/2014)**

Reference is made to your letter dated January 03, 2014. The ERC Secretariat acknowledges receipt of the revised proposal on January 06, 2014.

This is to inform you that the Ethics Review Committee (ERC) reviewed the documents submitted and is satisfied that the issues raised at the 220th B meeting held on 29th October, 2013 have been adequately addressed.

The study is granted approval for implementation effective this **January 07, 2014**. Please note that authorization to conduct this study will automatically expire on **January 06, 2015**. If you plan to continue with data collection or analysis beyond this date, please submit an application for continuing approval to the ERC Secretariat by **November 25, 2014**.

Any unanticipated problems resulting from the implementation of this protocol should be brought to the attention of the ERC. You are also required to submit any proposed changes to this protocol to SSC and ERC prior to initiation and advise the ERC when the study is completed or discontinued.

Yours faithfully,

DR. ELIZABETH BUKUSI,
ACTING SECRETARY,
KEMRI ETHICS REVIEW COMMITTEE

Topic theme “The Role of Poverty as a driver of the Non-Communicable Diseases and Injuries burden and the need for policy reframing in the context of Universal Health Coverage in Kenya”



SSPH+ ScienceFlashTalk

We hereby certify that

Kibachio Mwangi

has successfully completed the training

ThinkStoryline!®

offered by

Alexis and Kathrin Puhan

Competencies:

- Strengthen communication and presentation skills
- Learn to present a PhD thesis topic for a not specialized audience
- Learn to tell a story

Credits:

1 ECTS

Duration of the training and coaching:

From December 2017 to April 2018 via online training and a workshop in Zurich (approx. 30 hours of student workload)

Organisation:

Foundation Swiss School of Public Health (SSPH+)

Prof. Nino Künzli
Director SSPH+

Zurich, April 2018



Certificate of Attendance

This is to certify that

Dr. Joseph Muiruri Kibachio Mwangi

Attended and participated in the Access Accelerated event,
Strengthening Multi-Sector Collaboration in Support of Universal Health Coverage,
held on the margins of the 72nd World Health Assembly on
20 May 2019 in Geneva, Switzerland.

James Headen Pfitzer
Director, Access Accelerated

Mara Nakagawa-Harwood
Head of Implementation & Partnerships,
Access Accelerated

Chemin des Mines 9
P.O. Box 195
1211 Geneva 20 Switzerland

accessaccelerated.org
info@accessaccelerated.org
+41 22 338 32 00