CHRONIC RESPIRATORY DISEASES (CRD) IN AFRICA

Identifying social determinants and formulating appropriate, strategic responses

GRACE MARIE KU
VALÉRIA CAMPOS DA SILVEIRA
GUY KEGELS

With contributions from:
Patrick Develtere
Benoit Nemery
Bruno Marchal
Jean-Paul Dossou
Paul Bossyns
Karel Gyselinck

Correspondence to: GMKu at gku@itg.be

April 2021

TABLE OF CONTENTS

List of Figures

List of Tables

Appendices

LIST OF ABBREVIATIONS & ACRONYMS

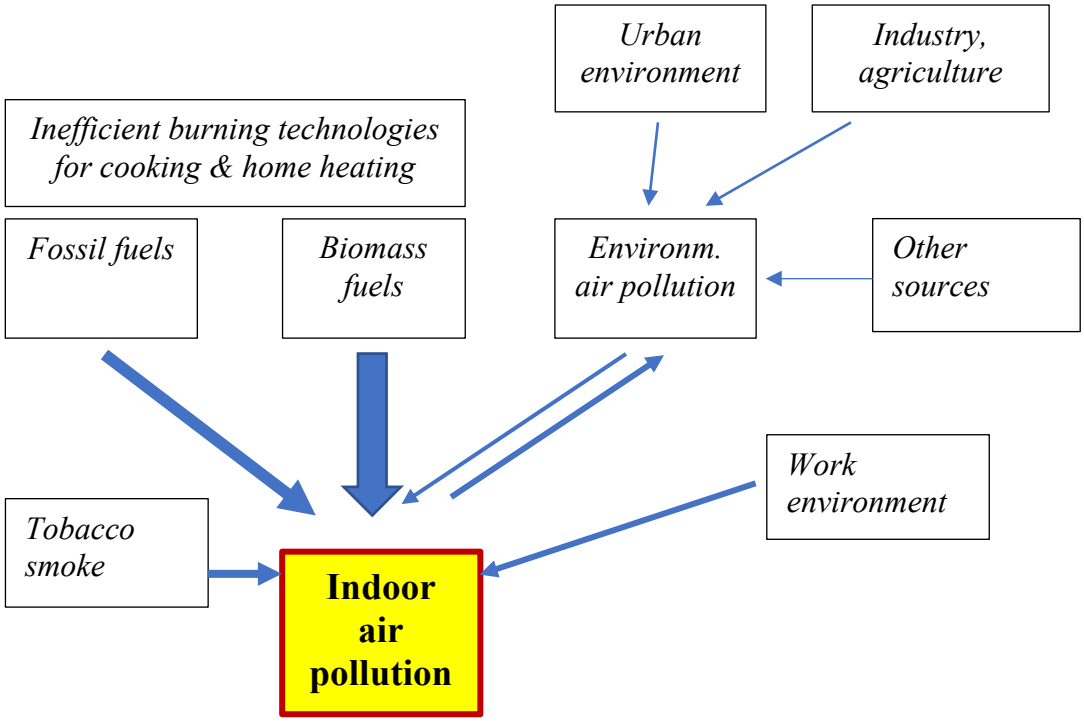
ABPS	Africa Biogas Partnership Programme
ACCA	Africa Centre for Clean Air (Uganda)
ACCP	Africa Clean Cities Platform
ACOS	Asthma-COPD Overlap Syndrome
AIRQUALI-4-ASMAFRI	Air Quality and Quality of life for Asthmatic Children in Africa
ART	Antiretroviral treatment
CNHU-HKM	Centre National Hospitalier de Pneumo-Phtisiologie (Benin)
CO	Carbon monoxide
COPD	Chronic Obstructive Pulmonary Disease
COPES-AOC	Communauté de Pratique en Ecosanté de l'Afrique de l'Ouest et Centrale
COVID-19	Corona Virus Disease 2019
CRD	Chronic Respiratory Diseases
CTCA	Centre for Tobacco Control in Africa (Uganda)
DGD	Directie-Generaal Ontwikkelingssamenwerking en Humanitaire Hulp (Belgium)
DRC	Democratic Republic of the Congo
EAC	East African Community
ECODEV	Ecole de développement local de Mauritanie
ECOWAS	Economic Community of West African States
Enabel	Belgian Development Agency
EU	European Union
FCDO	Foreign, Commonwealth and Development Office (formerly DFID - Department for International Development) (UK)
FCTC	Framework Convention on Tobacco Control (WHO)
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GIZ	German Development Agency (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GRET	Groupe de recherche et d'échanges technologiques (France)
HIC	High income countries
HIV	Human Immuno-deficiency Virus
HRSV	Human Respiratory Syncytial Virus
HSDP	Health Sector Development Plan
IDF	International Diabetes Federation
IDP	Inter-university Doctoral Programme
IDRC	International Development Research Centre (Canada)
IRD	Institut de recherche pour le développement (France)
JICA	Japan International Cooperation Agency
KCCA	Kampala City Council Authority (Uganda)
LMIC	Low- and middle-income country
MIT	Massachusetts Institute of Technology (USA)
MLI	Makerere Lung Institute (Uganda)
MoH	Ministry of Health
MSW	Municipal Solid Waste
NCD	Non-communicable Diseases
NEML	National Essential Medicines List
NGO	Non-Governmental Organisation

NHP	National Health Policy
OTAF	Observatoire du tabac en Afrique francophone
PAG	Plan d'action du Gouvernement
PLVIH	People living with VIH
PM	Particulate Matter
PPP	Purshasing Power Parity
PTB	Pulmonary Tuberculosis
RDIS	Rural Development Inter-Diocesan Service (Rwanda)
RRR	Resource Recovery and Safe Reuse
RSB	Rwanda Standards Board
SARA	Service Availability and Readiness Assessment (WHO)
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goal
SDH	Social Determinants of Health
SME/S	Self-management Education and Support
SNV	Dutch NGO
SSA	Sub-Saharan Africa
STEPS	Survey methodology on NCD developed by WHO
SWM	Solid Waste Management
The Union	International Union Against Tuberculosis and Lung Disease
TT	Tobacco Tactics (UK)
UICC	Union for International Cancer Control
UN	United Nations Organisation
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNEP	United Nations Environment Programme
UN-Habitat	United Nations Human Settlement Programme
UNICEF	United Nations International Children's Emergency Fund
Urban-KNOW	Knowledge in Action for Urban Equality
US$ / USD	United States Dollar
USAID	United States Agency for International Development
WHF	World Heart Federation
WHO	World Health Organization
WHO-PEN	Package of Essential NCD Interventions for Primary Health Care in Low Resources Settings

EXECUTIVE SUMMARY

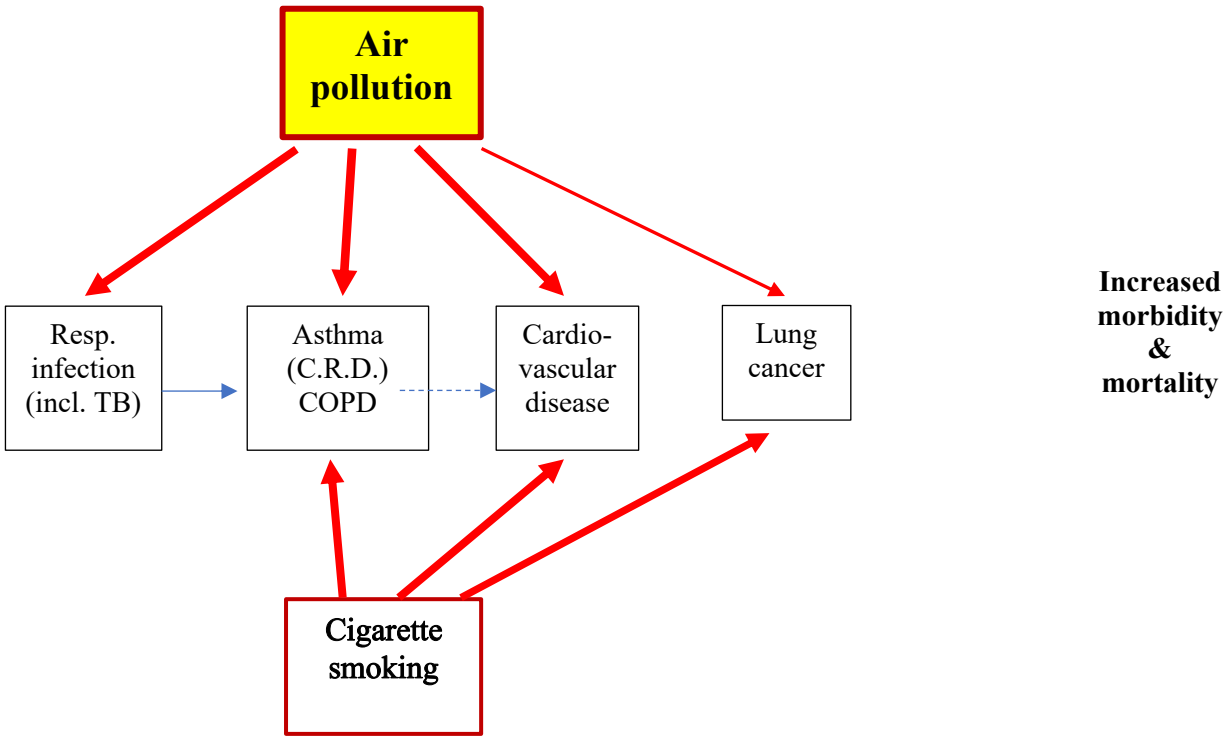
Chronic respiratory diseases (CRD – in this note restricted to *bronchial asthma* and *chronic obstructive pulmonary disease* or COPD), the entry point to the subject of this note, are an underestimated and largely neglected problem in Sub-Saharan Africa. *Underestimated* because frequency and severity are much higher than commonly intuited: several prevalence surveys on asthma yield figures of 4-14%, tending to be higher in urban environments, and for COPD results range from 4 to 25%, with the higher figures in rural areas and higher age groups. *Neglected* because in most countries of interest (the 11 Belgian Cooperation partner countries in SSA[1]) effective care for people suffering from CRD is mostly absent or highly defective. Especially frontline health services are devoid of knowledge and tools to assist people suffering from CRD.

The avoidable (non-genetic) fraction of the CRD burden can be attributed to several physical, chemical, social, cultural, demographic and biological determinants, in different causal layers and interconnected between them. Most visible among these is poor and worsening ***air quality***, in its turn driven by socio-demographic phenomena leading to accelerating rural-to-urban migration and mobility needs, by industrial and agricultural pollution, fossil fuel driven transport, inadequate waste management, polluting electric power generation, but also, to a surprisingly high degree, composed of *indoor* air pollution caused by inefficient burning technologies of unclean fuels (fossil and biomass), mainly for cooking, and by tobacco smoke, combined with insufficient ventilation. While urban environmental air pollution appears to contribute to increasing incidence and exacerbations of bronchial asthma attacks, indoor air pollution is the main culprit of high rates of COPD in rural areas, affecting mainly women and young children, causing lung damage and negatively affecting normal lung development from the foetal stage and onwards.



[1] Mauritania, Senegal, Burkina Faso, Benin, Niger, Guinea, Democratic Republic of Congo, Rwanda, Burundi, Uganda, Mozambique. In the World Bank classification these are Low Income Countries, except Mauritania, Benin and Senegal, which are classified as Lower Middle Income.

Air pollution, indoors as well as outdoors, does not only contribute to induce and exacerbate CRD; it is also a major determinant of *infectious* respiratory disease (including pulmonary tuberculosis), cardio-vascular disease and (lung) cancer. As such it is a background cause of multiple communicable and especially non-communicable diseases NCDs), the relative importance of which is now increasingly being recognised.



Polluted air shortens lives and makes many lives more miserable than they ought to be. In this respect, insalubrious air is in the same class as insalubrious water, defective sanitation and child undernutrition. And it may come as a surprise to many, but Sub-Saharan Africa's air is among the most polluted of all continents.

Given the multitude of elements influencing the quality of air people breathe, it is not unexpected that air quality can be directly linked to a surprisingly great number of the Sustainable Development Goals (SDGs): SDGs 3, 5, 7, 8, 11, 12 and 13 are all involved, directly or indirectly[2]. Given this extraordinarily broad field of application, one of the main challenges for action on improvement of air quality will have to consist in the formation of a widely shared and coherent ***discourse***, centred on (1) a common understanding of public goods (ideally leading to the notion of 'the right to clean air'), (2) a forward-looking vision based on a correct historical understanding of the present situation ('where are we now and how did we come to this?') and (3) a vision of development that is adapted to present-day global, national and local challenges ('what should be the way forward, given what we now know, in this day and age?').

A second consequence of the multitude of influencing elements is that, in the search for solutions, there will be ***no one size to fit all*** local situations. Although certain 'blanket' measures, to be applied across

[2] SDG 3 (healthy lives and well-being), in the fields of NCDs, tobacco use and availability of relevant essential medicines; SDG 5 (gender equality) pertaining to women's contribution to household chores including the fetching of biomass fuels for cooking and the cooking itself; SDG 7 (affordable and sustainable energy for all), focusing on clean fuels and technology; SDG 8 (decent work for all), focusing on secure working environments; SDG 11 (safe, resilient and sustainable cities, including solid waste management and control of fine particulate matter levels in cities); SDG 12 & 13 (sustainable consumption/production and combating climate change), pertaining to greenhouse gas emissions and sustainable forest management.

the board, do exist (e.g., in the areas of tobacco control, cleaner fuels, fiscal measures encouraging reduction of fossil fuels use, …), the most adequate sets of measures at local level will have to be informed by intelligent situation assessments. This will have to include, at least, *needs* assessment (technically defined); *technology* assessment (presently available vs. desirable technology); *demand* assessment (socially defined) and *stakeholder* assessment (power and influence differentials, who stands to gain, who stands to lose).

Regarding stakeholder assessment, a first attempt to map actors and organisations showing awareness of the problem and willingness to do something about it (in Africa) yields a somewhat surprisingly high number of 'alliances' at global and international level, many of them having some offshoots at national level (in Africa), though mostly in a dispersed manner and not (yet) leading to much action on the ground. To these can be added practical local initiatives, often by (inter)national NGOs, mostly introducing technological solutions like improved cooking stoves and more efficient fuels, with variable levels of success[3].

Activating this potential will need an effort at ***coalition building*** at local, national and international level, aiming at synergy and complementarity through coordination – ideally in a consultative and participatory manner.

Minimal and feasible ***actionable points*** – beside the already mentioned coalition building and formation of a coherent narrative (preferably making optimal use of the SDG agenda) – include the following:

- Closing the existing gap for ***CRD care*** by integrating a basic effective CRD care package at frontline and referral level in the healthcare system: responding to unmet demand;
- Ensuring ***clean air*** in all environments through (1) improvement of energy efficiency; (2) facilitation/encouragement of clean fuel use; (3) introduction and/or enforcement of secure working conditions where needed;
- ***Tobacco control*** through strengthened implementation of WHO's Framework Convention of Tobacco Control (FTCT);
- Initiating and strengthening of ***community and patient engagement*** for adequate attitudes and action.

In the spirit of this note it would not suffice to formulate a 'shopping list' of potential actions without providing shared ***guiding principles*** on which to base the selection and implementation of such interventions.

Although top-down blanket measures have their place in all this, it is strongly suggested to act on the basis of the following principle:

The more local the action to be undertaken, the more it should be based on specific local needs and demand assessment, ideally starting from existing but unmet demand. The postulated mechanism justifying this principle is that meeting unmet demand – combined with the provision of adequate and credible information – is more likely to create the necessary trust and confidence to go in search of upstream determinants, leading to the necessary preventive action. As the domain of prevention almost invariably involves difficult choices and behaviour changes, motivation is of the utmost importance.

A second principle, partly following from the previous one, is that a seemingly *a priori* low likelihood of immediate success is no reason for abandoning all action. Some goals take longer to achieve, but progress can be achieved in stages: 'signalling' the problem can be a necessary first step, putting it on the agenda and keeping it there, a second, and pushing the issue forward through constant monitoring can be necessary. It is good to keep in mind that the issues of chronic respiratory disease and air quality are far-ranging, touching upon numerous aspects of life and society. The problem is likely to be messy and complex and will require flexible attitudes and close follow-up in order to adjust to ever-changing circumstances.

[3] A list of actors and organisations so far identified can be found in annex to the present note.

Finally, it would seem obvious that, in all this, the ***healthcare sector*** is well-placed to take the lead and, moreover, has to shoulder the responsibility to ***lead by example***. The challenge appears to be urgent. Circumstances on the African continent are such that at present air quality is already among the worst on the planet, and further deterioration – and its consequences – is inevitable if adequate action is not undertaken. Clearly, henceforth this issue deserves to be a constant concern for international cooperation agencies like Enabel in dealing with Belgium's African partner countries.

CHAPTER I

WHY CHRONIC RESPIRATORY DISEASES?

Non-communicable diseases (NCD), of which Chronic Respiratory Diseases (CRD) constitute a major disease burden, are continuously on the rise in low- and middle- income countries (LMIC). The World Health Organization[4] estimates that, globally, about 3 million deaths (5% of all deaths) were caused by CRDs in 2015; more than 90% of these deaths occurred in LMICs. CRD is a typical example of a condition which is caused by a multitude of (social) determinants, a number of which can be acted upon; for instance, household air pollution from solid fuels was the predominant risk factor for CRD among women in sub-Saharan Africa in the Global Burden of Disease Study 2017.[5]

While CRD is defined by WHO[6] (undated) as diseases of the airways and other structures of the lung, some of the most common of which are chronic obstructive pulmonary disease (COPD), asthma, occupational lung diseases and pulmonary hypertension, for the purpose of this exercise, Enabel will restrict this term to collectively refer to the conditions Bronchial Asthma and Chronic Obstructive Pulmonary Disease. Bronchial asthma is generally characterised by intermittent, reversible airflow obstruction that presents as a life-long condition. COPD is a progressive disease characterized by irreversible lung damage causing obstruction in airflow. Emphysema and chronic bronchitis are the two most common conditions that contribute to COPD. Emphysema is a condition in which the air sacs at the terminal/smallest air passages are destroyed; chronic bronchitis involves chronic inflammation of the respiratory passages that leads to abnormally increased mucus production.

A. THE BURDEN OF BRONCHIAL ASTHMA

Worldwide, it has been reported that 339 million people suffer from asthma.[7] It is the most common chronic disease of childhood affecting 14% of children globally and rising.[8] It remains in the top twenty causes of disability in children globally.[9]

Although global mortality may be low at 420,000 deaths/year, avoidable factors play a large part in most asthma deaths.[10] It has been demonstrated that low-income populations, poor minorities and children living in inner cities suffer a disproportionately higher morbidity and mortality[11] and that over 80% of asthma-related deaths occur in LMICs.[12] It is important to note that asthma-related deaths in the 5–34 years age range have been designated as '*avoidable deaths*', which is a suitable marker of poorly performing health services.[13]

Bronchial asthma is a more important cause of disability and ranks 28th worldwide. During exacerbations, it causes decreased productivity and high activity impairment in adults[14] and increased school absenteeism in children.[15] Direct and indirect costs increase with increased severity; there would

[4] World Health Organization (undated) Chronic respiratory diseases. Available from: https://www.afro.who.int/health-topics/chronic-respiratory-diseases [Accessed 19 September 2020]
[5] GBD Chronic Respiratory Disease Collaborators. Prevalence and attributable health burden of chronic respiratory diseases, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet Respir Med. 2020 Jun;8(6):585-596
[6] WHO (undated) Op cit (footnote 1).
[7] The Global Asthma Report 2018. Auckland, New Zealand: Global Asthma Network 2018. Available from: http://www.globalasthmareport.org/Global%20Asthma%20Report%202018.pdf
[8] The Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease 2019 Report. Eur Resp J Available from: https://spiral.imperial.ac.uk/bitstream/10044/1/67856/6/13993003.00164-2019.full.pdf
[9] Ahmed R, Robinson R, Mortimer K, 2017. The epidemiology of noncommunicable respiratory disease in sub-Saharan Africa, the Middle East, and North Africa. Malawi Med J 29(2):203-211.
[10] The Global Asthma Report 2018. Op cit (footnote 4).
[11] Nunes AB, Oliveira AP, Jamanca A, Brito DV, Silva NM, Duarte S, Coelho A. Gestão e Controlo da Asma em Países de Expressão Portuguesa. Acta Med Port. 2020 Apr 1;33(4):269-274
[12] WHO 2020. Chronic Respiratory Diseases: Asthma. Available from: https://www.who.int/news-room/q-a-detail/chronic-respiratory-diseases-asthma
[13] Burney P, Jarvis D, Perez-Padilla R. The global burden of chronic respiratory disease in adults. Int J Tuberc Lung Dis. 2015 Jan;19(1):10-20
[14] Brakema EA, Tabyshova A, van der Kleij RMJJ, Sooronbaev T, Lionis C, Anastasaki M, An PL, Nguyen LT, Kirenga B, Walusimbi S, Postma MJ, Chavannes NH, van Boven JFM; FRESH AIR collaborators. The socioeconomic burden of chronic lung disease in low-resource settings across the globe - an observational FRESH AIR study. Respir Res. 2019 Dec 21;20(1):291
[15] Nunes et al. Op cit (footnote 8)

also be significant intangible costs, or costs related with unquantifiable losses, such as the decrease in quality of life, increases in pain or suffering, limitation of physical activities and job changes that have to be considered.

B. THE BURDEN OF CHRONIC OBSTRUCTIVE PULMONARY DISEASES (COPD)

In 2019, 384 million people were said to suffer from COPD globally. COPD is the third leading cause of death worldwide[16] with 3 million deaths/year; 90% of these deaths occur in LMICs.[17]

The condition is persistent and progressive. Disability from COPD escalates with increasing severity and contributes to decreased productivity and high activity impairment of up to 86%.[18] Direct, indirect and intangible costs increase progressively with disease progression. Increased societal costs and a greater impact on the health status were observed among those who have more severe disease (Foo et al., 2016).

C. THE EXTENT OF THE PROBLEM IN SUB-SAHARAN AFRICA

COPD and bronchial asthma are *de facto* considered as "neglected diseases" in sub-Saharan Africa (SSA). Both seem to have varying prevalence[19] although it has been observed that bronchial asthma has higher prevalence in urban areas, while COPD has higher prevalence in rural areas.

Owing to the projected increase in the urban population in sub-Saharan Africa, it is estimated that there may be an increase of at least 35% in the number of people with asthma by 2025.[20] It has been demonstrated that, in Africa, COPD affects more women and is documented to occur at a younger age as compared with the rest of the world.[21] The WHO estimates a loss of $56.6 billion (PPP) amounting to 5.1% of the GDP of the WHO African region secondary to decreased productivity due to CRDs.[22]

However, although the wide implications of increasing prevalence and increasing severity are recognized, there are serious challenges for effective action. Primary prevention, and early accurate diagnosis and sustainable availability of affordable medicines and diagnostic tests which are fundamental in optimal management of bronchial asthma and COPD are big challenges.[23] Many people, including health care workers and government officials, are mostly unaware of the different factors that could be damaging to respiratory health[24] and that could lead to the development and worsening of both bronchial asthma and COPD. A number of these risks could be mitigated through implementation of strategic actions.

---

[16] The Global Strategy. Op cit page 2.
[17] Ahmed et al., 2017. Op cit page 2.
[18] Brakema et al., 2019. Op cit page 2.
[19] van Gemert F, Kirenga B, Chavannes N, Kamya M, Luzige S, Musinguzi P, Turyagaruka J, Jones R, Tsiligianni I, Williams S, de Jong C, van der Molen T. Prevalence of chronic obstructive pulmonary disease and associated risk factors in Uganda (FRESH AIR Uganda): a prospective cross-sectional observational study. Lancet Glob Health. 2015 Jan;3(1):e44-51
[20] van Gemert F, van der Molen T, Jones R, Chavannes N. The impact of asthma and COPD in sub-Saharan Africa. Prim Care Respir J. 2011 Sep;20(3):240-8
[21] Brakema et al., 2019. Op cit page 2.
[22] WHO Regional Office for Africa. A heavy burden: the productivity cost of illness in Africa 2019. Available from: https://www.afro.who.int/sites/default/files/2019-03/Productivity%20cost%20of%20illness%202019-03-21.pdf. Note: In this publication, the WHO defines productivity costs as *indirect costs that occur when the productivity of individuals is affected by illness, treatment side effects, disability or premature death. They are usually estimated in terms of lost earnings due to sickness.*
[23] van Gemert FA, Kirenga BJ, Gebremariam TH, Nyale G, de Jong C, van der Molen T. The complications of treating chronic obstructive pulmonary disease in low income countries of sub-Saharan Africa. Expert Rev Respir Med. 2018 Mar;12(3):227-237.
[24] Van Gemert et al., 2015. Op cit footnote 16.

CHAPTER II

"WHERE DO WE WANT TO BE?"

Enabel, in accordance with its vision, mission and core values, seeks to develop a multi-disciplinary, multi- actor and synergistic approach in terms of primary and secondary prevention by acting on [1] the social and structural determinants of health (SDH), [2] community engagement, and [3] strengthening of health systems and improving the quality of healthcare, in its partner countries in Africa, particularly Benin, Burkina Faso, Burundi, the Democratic Republic of Congo (DRC), Guinea, Mauritania, Mozambique, Niger, Rwanda, Senegal, and Uganda.

The actions are envisioned to go beyond medical management of CRDs to also address wider structural and social determinants that significantly contribute to the development and worsening of bronchial asthma and COPD.

A. GENERAL OBJECTIVE OF THE STUDY

This research was conducted to formulate specific and feasible strategies that could inspire future interventions of the Belgian Development Cooperation to address, directly and indirectly, the issues of bronchial asthma and COPD, in partner countries in Africa.

B. SPECIFIC OBJECTIVES

To this end, this research aimed specifically, *to the extent that information is available*, to:

1. Give an overview of the burden of CRD-related problems in LMIC and their main determinants in Africa, in particular in Benin, Burkina Faso, Burundi, DRC, Guinea, Mauritania, Mozambique, Niger, Rwanda, Senegal, and Uganda;
2. Prepare an inventory of current CRD-relevant policies and programmes in the partner countries;
3. Analyse position, potential and strength of different stakeholders at the levels of the partner countries and of the Belgian International Cooperation;
4. Identify and justify relevant axes of support, in the broad policy perspective of Primary Health Care and Universal Health Coverage; and more specifically looking at healthcare delivery;
5. Discuss the relevance and feasibility of innovative approaches to address relevant social determinants of health;
6. Identify opportunities to liaise with international organizations already working on CRD; and
7. Identify opportunities for synergy of CRD-related activities in current interventions of Enabel or other actors of the Belgian international cooperation in the partner countries, and in line with the global challenges identified by Enabel in the 2030 strategy (Urban development, Equity, Climate Change, Migration, Peace and security).

CHAPTER III

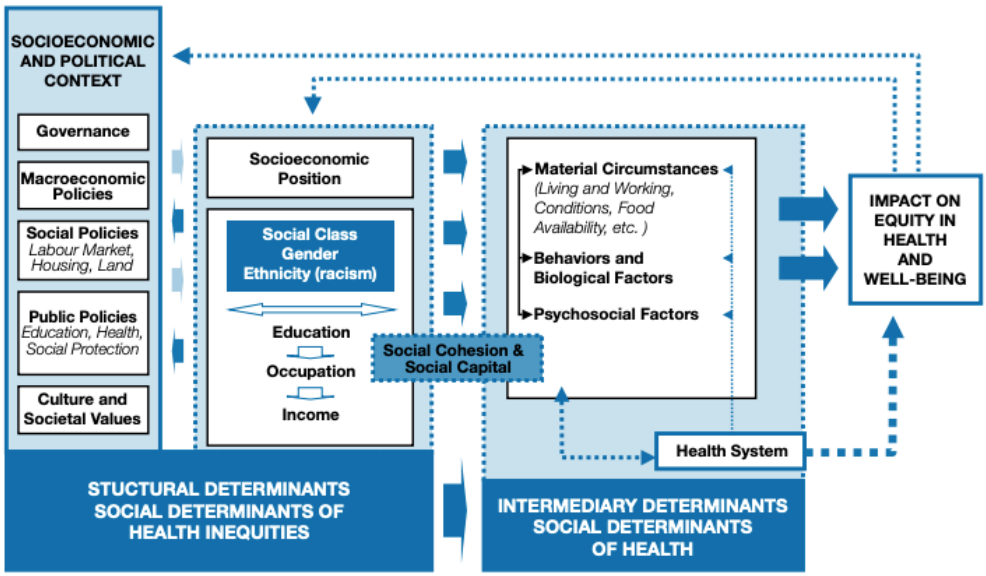
ESTABLISHING "*WHERE ARE WE NOW*", PART 1: THE CONCEPTUAL FRAMEWORK

A. WHO Framework on the Social Determinants of Health

The first step in realizing what specific and appropriate responses could be formulated was to establish the structural and social determinants affecting asthma and COPD that need to be and could be addressed.

This was done using a conceptual framework for action on SDH proposed by the WHO[25] wherein they identified two types - structural and social - and which encompasses the general socioeconomic and political contexts; the socioeconomic position of the individual that includes social class, gender, ethnicity, education, occupation and income; and considering the individual's material circumstances, behaviour and biological factors, and psychosocial factors (Figure 1).

Figure 1. WHO Conceptual Framework for Action on the Social Determinants of Health



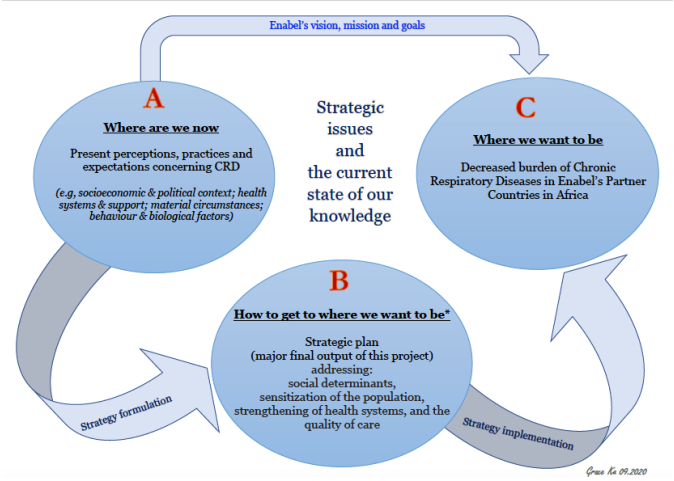
Material circumstances are the physical/material conditions which an individual is in or has, for instance *housing and environment*, *financial means* to purchase needs, and the *physical work environment*. *Psychosocial circumstances* are situations that occur or the fear that these will occur affecting the person directly involved and brought about by their relationship between their *mental and emotional wellbeing* and the *environment*. *Behavioural factors* are the factors related to the potential and expressed capacity (mentally, physically, and socially) of human individuals or groups in response to internal and external stimuli, which may be affected by personality, the situation, or are a reaction to the environment. *Biological factors* are the genes, drugs, neural systems, hormones, microorganisms cell cultures, human endoparasites and components from microorganisms that can cause damage to health in humans.[22]

[25] World Health Organization (2010) Conceptual Framework for Action on the Social Determinants of Health. Available from: https://apps.who.int/iris/bitstream/handle/10665/44489/9789241500852_eng.pdf;jsessionid=66F13D7AC7BACD15BE2A7E7A919C2B02?sequence=1 [Accessed 17 Sept 2020].

B. Bryson and Alston's ABCs of Strategic Planning

In order for Enabel to strategically respond with appropriate and feasible interventions, we used a framework adapted from Bryson and Alston's ABCs of Strategic Planning[26] (Figure 2): *A* is establishing where you are, *C* is where you want to go, and *B* is figuring out how to get to *C*. The strategy (output of *B*) is logically informed by both *A* and *C,* plus what is known about possible, feasible effective actions.

Figure 2. Proposed Enabel CRD Response Strategic Planning Framework



1. "A. Where are we now?"
   This entailed [a] collection of information on the *current structures* in the partner countries, considering governance, policies, cultures and values, to the extent available; [b] establishing relevant social and structural determinants making use of the WHO Conceptual Framework for Action on the Social Determinants of Health; and [c] analysing these considering the pathophysiology and case management of COPD and bronchial asthma.
2. "B. How to get where we want to be"
   Strategic future interventions of Enabel were formulated and/or adapted to address the challenges identified to be most susceptible, based on the analysis from the preceding.
3. "C. Where we want to be"
   This is currently an *aspirational aim* at achieving a decreased burden of CRD in Enabel's partner countries in Africa, which could be achieved through implementation of specific strategies, produced through "B".

The expected output is a *theory on how the goals can be reached* based on valid information, formulated as a hypothesis to be tested through implementation and monitoring and evaluation, and aimed towards achieving "*C: Where we want to be*". Activities in this research were limited to "*A: Where are we now*" and "*B: How to get where we want to be*" of the Enabel CRD Response Strategic Planning Framework, and the possible initial steps that could be taken towards implementation of the formulated strategies.

[26] Bryson JM & Alston FK. Creating your strategic plan: a workbook for public and non-profit organizations (3rd ed.). 2015: Jossey-Bass Publishers, USA.

CHAPTER IV

ESTABLISHING "*WHERE ARE WE NOW*", PART 2: THE METHODOLOGY

A. SCOPING REVIEW OF LITERATURE

A scoping review of literature on the burden of CRD and CRD-related problems and their main determinants in LMICs, specifically in the African partner countries, was performed. This included, to the extent where these were available, scientific publications, policies (including implementation), programme/project documents and reports, web sites of organisations/programmes and data bases.

1. Scientific literature review

Search for scientific publications was conducted using specific keywords: [[chronic obstructive pulmonary disease OR COPD OR chronic bronchitis OR pulmonary emphysema OR bronchial asthma] AND [Africa]] AND

a. [social determinants] OR [burden]; OR
b. [risk factors]; OR
c. [management].

Only publications within the past 10 years and written in English, French or Portuguese were considered. Article sifting was done systematically: retrieved publications were screened through the titles; abstracts of the chosen articles were retrieved and individually reviewed. Full articles of the sifted abstracts were scrutinized and selected; only articles that are relevant to this study's objectives were included in the final selection. Information relevant to the study was retrieved.

2. Country-related documents review

Search for "grey" literature and other pertinent documents from partner country governments, international cooperation organizations, etc, as from the year 2000, written in either English, French or Portuguese was conducted using the Google search engine.

A variety of keywords (or combination of them) related to CRD were explored. Numerous web portals and databases from governments, international development organisations, civil associations and non-governmental organisations, United Nations and International bank agencies, universities and training institutions were accessed.

B. SEMI-STRUCTURED INTERVIEWS

Expert opinion was sought to supplement and enrich local data collected on CRD-related experiences in African partner countries, considering restrictions due to the COVID-19 pandemic and limitations in time. Respondents were identified via development agencies and contacts in the partner countries; they were selected purposively and pragmatically. A question guide was prepared in English and French (Appendix I). Respondents were asked to fill-out a prepared questionnaire via e-mail.

Analysis of the data was done manually.

CHAPTER V

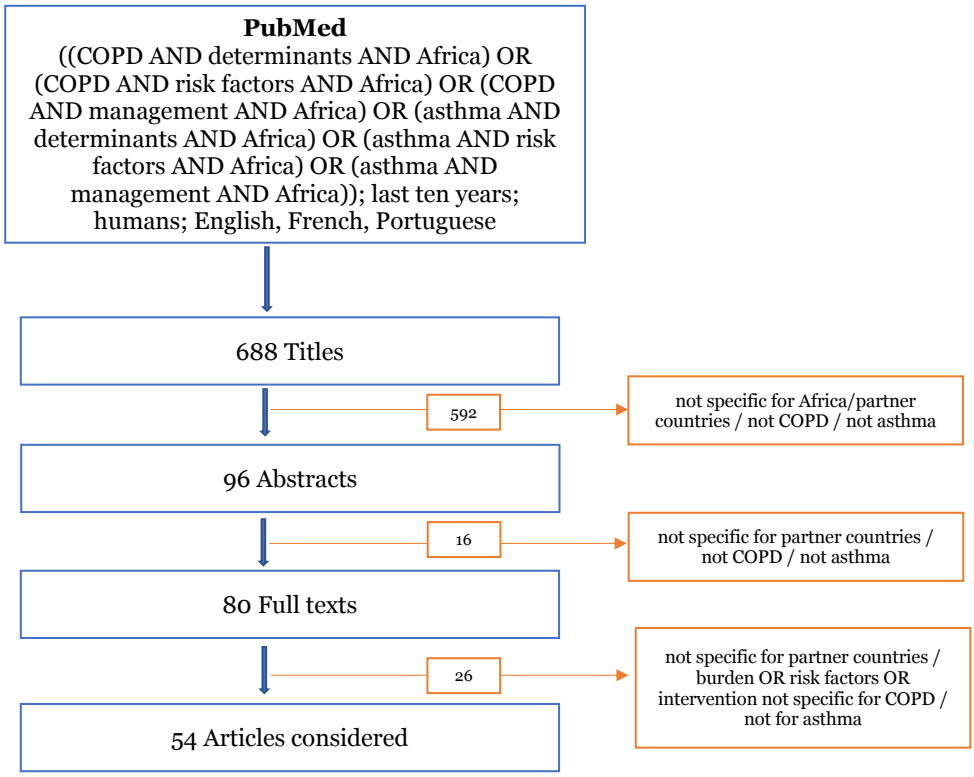
"WHERE ARE WE NOW?"

A. RESULTS

1. LITERATURE REVIEW

The literature search in PubMed yielded 688 titles, sifted to 96 abstracts. The abstracts were scrutinised, and 80 full texts were assessed. A total of 54 articles fulfilled criteria and were reviewed (Figure 3), and pertinent information was retrieved. The articles were classified as to: burden of asthma or COPD or both; risk factors for asthma or COPD or both; current state of affairs in specific countries (interventions, clinical management, etc), where available (Appendix II).

Figure 3. Article sifting of published literature



2. DOCUMENTS REVIEW

Country documents including country-specific grey literature pertinent to the topic were reviewed and information regarding policies and actions on CRDs and the identified socio-structural determinants, where available, were retrieved.

3. SEMI-STRUCTURED INTERVIEWS

A total of 12 filled out questionnaires were collected from six of the partner countries, distributed as follows: Benin=2, Burundi=2, Guinea=1, DRC=5, Niger=1, and Uganda=1. We were not able to get any response from Burkina Faso, Mauritania, Mozambique, Rwanda, and Senegal.

B. DISCUSSION

1. THE PATHOPHYSIOLOGY OF BRONCHIAL ASTHMA

Bronchial asthma has multifactorial modifiable and non-modifiable causes, exposure and effects of which may start from foetal life. Asthma onset may occur as early as infancy as well as during adulthood. Persistence and severity are multifactorial in nature and include exposure to asthmagens and irritants including air pollutants, and irregular or non-usage of asthma medications which may be attributed to poor adherence and/or poor access (e.g., non-availability of medications), among others. In the later years of the condition, there is persistent decline in lung function; this loss of lung function may also be the result of coexisting lung diseases, particularly COPD. The prevalence of anxiety and depression is increased among people with asthma, especially among those in poor control of the condition.[27] The presence of asthma symptoms and a poorer state of mental well-being would increase demands on healthcare and negatively affect productivity and quality of life. Asthma-COPD overlap syndrome (ACOS) has a higher disease burden than either asthma or COPD alone; there are more frequent exacerbations with increased demands for health services, poorer quality of life, a more rapid decline in lung function, and higher mortality.[28]

Diagnosis of bronchial asthma is made through a combination of a person's clinical signs and symptoms; medical and family history; exposure to irritants, allergens and occupational dust; use of diagnostic modalities to measure lung function (pulmonary function test or spirometry) and blood oxygenation (arterial blood gases); and lung imaging studies (e.g., chest X-ray to rule out other lung pathologies).

Individual treatment[29] includes [1] lifestyle modifications (e.g., avoidance of triggers; smoking cessation; increasing fruit and vegetable intake; maintaining ideal body weight; regular physical activity); [2] use of medications directed towards control of the condition (e.g., inhaled long-acting beta-agonists + corticosteroids; leukotriene modifiers; etc) and management of acute attacks or exacerbations (e.g., inhaled short-acting beta-agonists; inhaled and oral/systemic corticosteroids; oxygen supplementation as needed); and [3] other preventive measures (e.g., immunizations against influenza, pneumonia).

2. THE PATHOPHYSIOLOGY OF COPD

The current paradigm is that long-term exposure to irritant gases or particulate matter causes an enhanced or abnormal inflammatory response beyond the normal immune response in the airways, limiting airflow.[30] Exposure to these substances *in utero*, as well as low birth weight and premature birth additionally predisposes the person to have impairments in lung functioning and to develop COPD[31]. While a genetic cause has been implicated, this is to a much lesser degree as compared to asthma.

The inflammatory response and resulting airway obstruction worsen through time, especially if the causative agents are not eliminated and proper clinical management including lifestyle modification is not instituted. Worsening irreversible obstruction can eventually lead to complications such as congestive heart failure. Daily life activities become more limited with disease progression. The condition also affects mental health; it has been noted in a meta-

[27] Scott KM, Von Korff M, Ormel J, Zhang M, Bruffaerts R, et al. Mental Disorders among Adults with Asthma: Results from the World Mental Health Surveys. General Hospital Psychiatry. 2007; 29(2): 123-133.

[28] Freiler, John. The asthma-COPD overlap syndrome. Federal Practitioner. September 2015;19S-23S.

[29] Global Initiative for Asthma. Global Strategy for Asthma Management & Prevention, 2020 update. Available from: https://ginasthma.org/wp-content/uploads/2020/06/GINA-2020-report_20_06_04-1-wms.pdf [accessed: 19 January 2021].

[30] MacNee, William. Pathogenesis of Chronic Obstructive Pulmonary Disease. Proceedings of the American Thoracic Society. November 2005; 2(4): 258–266.

[31] Savran O, Ulrik CS. Early life insults as determinants of chronic obstructive pulmonary disease in adult life. International Journal of Chronic Obstructive Pulmonary Disease. February 2018; 13: 683-693

analysis by Matte et al[32], that the prevalence of depression among people with COPD (20.7%) was twice as high as in the control group (10.0%). The inability to perform a number of daily activities, premature retirement and premature death all contribute to indirect costs and economic losses. It is also equally important to consider intangible or unquantifiable losses secondary to increased pain and suffering and decreased quality of life.

Akin to bronchial asthma, diagnosis of COPD is made through a combination of a person's clinical signs and symptoms; medical and family history; exposure to irritants including cigarette smoke and occupational dusts; use of diagnostic modalities to measure lung function (pulmonary function test) and blood oxygenation (arterial blood gases); and lung imaging studies (e.g., chest X-ray to check for pulmonary hyperaeration suggestive of pulmonary emphysema or increased bronchovascular markings suggestive of chronic bronchitis).

Treatment[33] includes [1] lifestyle modifications (e.g., avoidance of irritants; smoking cessation; increasing fruit and vegetable intake; maintaining ideal body weight; regular physical activity); [2] use of medications directed towards control of the condition ("controllers", e.g., inhaled long-acting beta-agonists + corticosteroids; inhaled long-acting muscarinic antagonists; xanthine derivatives, etc) and management of acute attacks or exacerbations ("relievers", e.g., inhaled short-acting beta-agonists; inhaled and systemic corticosteroids; oxygen supplementation); and other preventive measures (e.g., immunizations against influenza, pneumonia). Oxygen supplementation will almost always be required with disease progression, either delivered intermittently or continuously depending on the stage of severity.

3. THE PERTINENT SOCIAL AND STRUCTURAL DETERMINANTS THAT CONTRIBUTE TO THE CAUSATION AND POOR CONTROL OF BRONCHIAL ASTHMA AND COPD IN THE PARTNER COUNTRIES & ANY ONGOING ACTIONS TO ADDRESS THESE

Several social and structural determinants which may contribute to disease causation and/or progression in the partner countries were identified, together with the current state of affairs and ongoing actions, if any. The identified social determinants are listed in Table 1.

Table 1. Social and structural determinants of asthma and COPD in the partner countries.

MATERIAL CIRCUMSTANCES	PSYCHOSOCIAL CIRCUMSTANCES	BEHAVIOURAL FACTORS	BIOLOGICAL FACTORS
1. Rapid urbanization & poor urban planning 2. Poor air quality 3. Lack of adequate indoor ventilation 4. Sub-optimal occupational health and safety practices 5. Poor access to healthy food 6. Poor access to healthcare 7. Lack of knowledge on CRDs & low level of education	1. Stress 2. Poor psychosocial support 3. Stressful living relationships	1. Tobacco use 2. Food choices 3. Beliefs and norms	1. Genetics 2. Recurrent respiratory tract infections 3. ? COVID-19 4. Pulmonary tuberculosis (PTB) 5. HIV 6. Helminth infections

[32] Matte DL, Pizzichini MMM, Hoepers ATC, Diaz AP, Karloh M, et al. Prevalence of depression in COPD: A systematic review and meta-analysis of controlled studies. Repiratory Medicine. 2016 August; 117: 154-161.

[33] Global Initiative for Chronic Lung Diseases (GOLD). Global Initiative for the Diagnosis, Management & Prevention of COPD 2020 Report. Available from: https://goldcopd.org/wp-content/uploads/2019/12/GOLD-2020-FINAL-ver1.2-03Dec19_WMV.pdf [accessed: 19 January 2021).

a. **Material circumstances**

i. Rapid urbanization and poor urban planning

Uganda has the highest urbanization rate globally, at almost 3x the world average.

In 2019, the rate of urbanization, or the average annual change in proportion of urban population, in the African partner countries were all higher than the world average of +2.1%. It ranges from +3.2% (Rwanda) to +5.99% (Uganda), with Uganda having the highest rate of urbanization in the whole world.[34]

The rapidly increasing population density in urban environments coupled with poor urban planning in the partner countries contribute to environmental degradation. The increased use of unclean energy and (poorly regulated) means of transportation contribute to greater air pollution; there is a higher rate of waste generation coupled with improper disposal; the increasing numbers of the population lead to a higher inability of local governments to address health needs; and poor urban planning could lead to a more condensed distribution in certain locations, flourishing of 'slum'-like settlements, and admixing of residential and commercial locations, with lesser trees and green areas.

Studies in Uganda demonstrated association of asthma with a strong rural-town-city risk gradient and 'urbanicity';[35] a more than twice higher prevalence of asthma in the urban setting (4.4% rural, 9.7% urban);[36] and urbanization being the primary driver of asthma.[37]

Rapid urbanization is a "rite of passage" gone through by low-income countries in transition to middle-income classification. Similar to other countries undergoing these developments, SSA and the partner countries do not seem to be prepared in mitigating the risks and addressing the challenges related to rapid population growth.[38] Local responses to high population growth rate have been much influenced by politics in partner countries and are not consistent with the needs inherent to this demographic reality.

ii. Poor air quality

Air pollution is progressively increasing in severity through the years; if unaddressed, deleterious effects on respiratory function, among others, can only become worse.

Across Africa, increased motor vehicle use, industrial growth, dust storms, and persistent use of biomass fuel for cooking, heating and indoor lighting result in *air pollution* that is choking the continent's inhabitants. Outdoor air pollution with higher levels of carbon monoxide (CO), nitrogen dioxide, ozone, particulate matter and sulphur dioxide has been documented in urban areas. On the other hand, air pollution due to biomass fuel usage in homes is more predominant in rural areas.[39]

---

[34] Information from: https://knoema.com/WBWDI2019Jan/world-development-indicators-wdi

[35] Mpairwe H, Namutebi M, Nkurunungi G, Tumwesige P, Nambuya I, Mukasa M, Onen, C, Nnaluwooza M, Apule B, Katongole T, Oduru G, Kahwa J, Webb EL, Lubyayi L, Pearce N, Elliott AM. Risk factors for asthma among schoolchildren who participated in a case-control study in urban Uganda. Elife. Nov 2019;8:e49496.

[36] Siddharthan T, Grigsby M, Morgan B, Kalyesubula R, Wise RA, Kirenga B, Checkley W. Prevalence of chronic respiratory disease in urban and rural Uganda. Bull World Health Organ. 2019 May 1;97(5):318-327

[37] Morgan BW, Siddharthan T, Grigsby MR, Pollard SL, Kalyesubula R, Wise RA, Kirenga B, Checkley W. Asthma and Allergic Disorders in Uganda: A Population- Based Study Across Urban and Rural Settings. J Allergy Clin Immunol Pract. 2018 Sep-Oct;6(5):1580-1587.

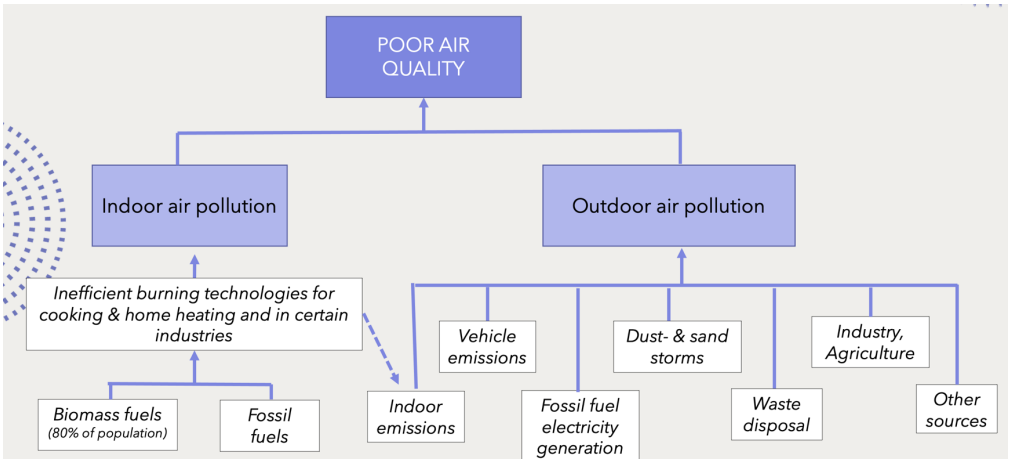
[38] https://www.csis.org/analysis/urbanization-sub-saharan-africa

[39] Ahmed R, Robinson R, Mortimer K. The epidemiology of noncommunicable respiratory disease in sub-Saharan Africa, the Middle East, and North Africa. Malawi Med J. 2017 Jun;29(2):203-211

It is important to note that as of 2017, the entire populations in all the partner countries are considered exposed to PM2.5 levels exceeding the annual mean value of 10 μg/m3 as set by WHO.[40]

Figure 4 illustrates the contributors to poor air quality in SSA.

Figure 4.Causes of indoor and outdoor pollution that decreases quality of air



Biomass fuels

Traditional cookstoves utilizing biomass fuels are the main cause of indoor pollution and an important source of outdoor pollution. Women & children are the most affected groups.

Smoke from biomass fuels has been shown to contain numerous toxic compounds including carbon monoxide, particulate matter (PM), sulphur oxides (SOx), nitrogen oxides (NOx), polycyclic aromatic hydrocarbons (PAH), aldehydes, free radicals, and volatile organic compounds.[41] It is the main cause of indoor air pollution; at the same time, it is also an important source of outdoor air pollution accounting for 10-30% of fine particulate matter.[42]

Cookstove innovations which utilise the same biomass fuels (wood, charcoal, straw) have shown disappointing results[43], and were still noted to emit considerable amounts of noxious gases (particularly CO, NOx and PAH) and particulate materials including $PM_{2,5}$ and PM_{10}. [44] However, there seem to be more promising innovations with less emissions.

The Clean Cooking Alliance (CCA) is an initiative hosted by the United Nations Foundation that works with some of the partners – Burkina Faso, DRC, Niger, Rwanda and Uganda – on driving consumer demand, mobilizing investment to build a pipeline of scalable businesses, and fostering an enabling environment that allows the sector to thrive.[45]

[40] https://www.who.int/news-room/fact-sheets/detail/ambient-%28outdoor%29-air-quality-and-health

[41] Capistrano SJ van Reyk D, Chen H, Oliver GB. Evidence of Biomass Smoke Exposure as a Causative Factor for the Development of COPD. Toxics. 2017 December; 5 (4): 36. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5750564/pdf/toxics-05-00036.pdf [accessed 19 January 2021].

[42] Awopeju OF. Chapter on Health Effect of Biomass Fuel Smoke from Environmental Emissions. 2020 November: IntechOpen. Available from: https://www.intechopen.com/books/environmental-emissions/health-effect-of-biomass-fuel-smoke [accessed 19 January 2021].

[43] Ray I, Smith KR. Towards safe drinking water and clean cooking for all. *Lancet Glob Health* 2021; 9: e361–65

[44] Mitchell EJS, Ting Y, Allan J, Lea-Langton AR, Spracklen DV, McFiggans G, Coe H, Routledge MN, Williams A & Jones JM. Pollutant Emissions from Improved Cookstoves of the Type Used in Sub-Saharan Africa. Combustion Science and Technology. 2020; 192 (8): 1582-1602.

[45] https://www.cleancookingalliance.org/what-we-do/index.html

CCA is working with the ISO organization for standards for clean cookstoves and clean cooking solutions,[46] assuring a better and standardized measurement of cookstove performance, household air pollution and exposure to $PM_{2,5}$ and CO.

In Rwanda, CCA has supported Mimi Moto (a Netherlands-based cookstove designer) and *Inyenyeri (*a Rwandan for-profit social benefit company) to test and improve the Mimi Moto cookstove that utilizes biomass pellets. The pellets are locally produced in Rwanda making use of sustainably-sourced biomass feedstock (e.g., eucalyptus branches). ISO standard measurements showed that use of this stove reduces climate- and health- damaging emissions almost as much as a liquid petroleum gas stove. However, adoption and two-year retention rates for use of the Mimi Moto cookstove is low at 38% and 22% respectively; this may be due to bad experiences from other cookstoves (Lucia, Modified Champion and Philips) previously offered by the same company, and the lack of funds to pay for the lease of the cookstove and to purchase the fuel pellets.[47]

CCA supported a Netherlands-based designer, Mimi Moto, to test and improve a biomass stove resulting in a high-performing biomass stove making use of pellets from eucalyptus wood waste in Rwanda.
The same company also developed technology transforming coffee husk waste to biomass pellets in Uganda.
- https://mimimoto.nl/cases/

Still in Rwanda, energy efficient cookstoves (Save80) were distributed in a UNHCR (United Nations High Commissioner for Refugees) refugee camp and pulmonary function was tested among the women who did the cooking at baseline and after nine months. Results showed that use of improved cookstoves improved airflow especially among those with pre-existing respiratory obstruction.[48]

The Senegalese non-governmental organization (NGO) *des villageois de Ndem* in partnership with Initiative Développement des Projets Solidaires (a French NGO) started a project of producing briquettes out of peanut shells making use of an industrial press in Mbacké-Touba and in the neighbouring departments. In order to optimize the use of these briquettes, specific adapted stoves have been developed. Compared to conventional stoves, the adapted stoves generate less smoke, reduce cooking time and generate savings in the cooking budget of around 25%. As part of the project, a company – *Yaakaar Environment* – was created. Ultimately, it is foreseen to manage and develop operational activities independently within the framework of a sustainable economic model.[49]

In Senegal, ONG des villageois de Ndem in partnership with Initiative Développement des Projets Solidaires produce peanut shell briquettes for use in a specific adapted stove that is more efficient and generates less smoke.
Briquette annual production capacity is high at 100 tons; these are distributed through a network of women's groups and dealers. Professional customers such as grain processors and bakers are also a target for distribution.

[46] https://www.iso.org/standard/66521.html
[47] Jagger P & Das I. Implementation and scale-up of a biomass pellet and improved cookstove enterprise in Rwanda. Energy for Sustainable Development. 2018; 46: 32-41.
[48] Wolff F, Kothe H, Mubiru A, Gashirabake J, Uwimana I, Dalhoff K. Positive impact of improved cookstove usage on respiratory health in Congolese refugees: a prospective cohort study. Environ Sci Pollut Res Int. 2020 Feb;27(4):4509-4512
[49] Coordination Sud (2019) Les spécificités de l'accès à l'énergie dans les pays en développement. Paris, France ; ONG des Villageois de Ndem at http://www.ndem.info/; Initiative Développement at https://id-ong.org/

In Uganda, organic waste is *recycled* to produce charcoal briquettes that are then used as an affordable source of energy for cooking by low-income households. These small businesses are supported by *Urban-KNOW (Knowledge in Action for Urban Equality)*[50] and *Resource Recovery and Safe Reuse (RRR) Project Phase II and III*.[51] Urban-KNOW is a consortium of local and international researchers, academics and community partners. They work on capacity building activities, trainings, interventions and knowledge sharing through peer-to-peer learning and exchanges across the entire energy briquettes value chain. RRR Project Phases II and III work on the up-cycling of treated liquid and solid waste streams such as municipal solid waste, market waste, faecal sludge, agro-industrial waste, animal waste and wastewater for the recovery of nutrients, energy and water. RRR project is implemented by Kampala Capital City Authority (KCCA), co-funded by the German Development Cooperation (GIZ) the Swiss Agency for Development and Cooperation (SDC).[52]

Road traffic emissions

The road fleet in cities of SSA is mainly composed of used vehicles exported from Europe and the Americas, majority of which are 10 years or older and most of which may be lacking in emission-reduction technology. Motorcycle use is also remarkable, including as a mode of public transport.

Emissions from road fleets, including motorcycles, are a significant contributor to air pollution reaching the population in general and specifically road professionals, informal vendors, and the vast population working at the roadsides in open markets, many of whom are children and women.[53,54]

Transport policies in sub-Saharan Africa tend to favour automobiles,[43] with little or no consideration for pedestrians and non-motorized vehicles.

Furthermore, usage of vehicles in highly congested areas would mean driving at low speed, inducing higher fuel consumption and higher emissions. Traffic congestion is a product of a number of factors that include not only the high density of people but also ineffective public transport, having no or substandard cycling and walking infrastructure, poor road discipline, etc. In addition, vehicle emission standards are inadequate and poorly enforced in most countries in SSA.[55] Hopefully, this will soon be addressed: in February 2020, the *Economic Community of West African States* (ECOWAS) meeting in Ouagadougou adopted the first *African regional fuel economy roadmap*; a comprehensive set of regulations for introducing cleaner fuels and vehicles in the region.[56] It is good to note that Burkina Faso has active air pollutant emissions standards for automobiles and mopeds since 2001.[57]

[50] https://www.urban-know.com/programme

[51] https://www.shareweb.ch/site/Water/resources/RsEAU%20Library/Aguasan%20Workshop%202017/Hofstetter%20Eileen%20Resource%20Recovery%20and%20Reuse%20Kampala.pdf

[52] https://www.urban-know.com/post/seeding-community-briquette-groups

[53] Mbelambela E.P., Hirota R., Eitoku M. et al (2017) Occupation exposed to road-traffic emissions and respiratory health among Congolese transit workers, particularly bus conductors, in Kinshasa: a cross-sectional study. *Environmental Health and Preventive Medicine* 22:11 https://environhealthprevmed.biomedcentral.com/track/pdf/10.1186/s12199-017-0608-9.pdf

[54] Haq G. and Schwela D. (Ed.) (2012) Transport and Environment in Sub-Sahara Africa. The TEST Network, Stockholm Environment Institute, Environment Department, University of York, UK. Available from: https://www.researchgate.net/publication/263969502_Transport_and_Environment_in_Sub-Saharan_Africa/link/00b7d53c77bcc603fc000000/download [accessed 7 February 2021].
Schwela, D. and G. Haq (2013) Transport and Environment in Sub-Saharan Africa (policy brief). Stockholm Environment Institute Policy Brief, York, UK. Available from: https://mediamanager.sei.org/documents/Publications/sei-pb-2013-africa-transport.pdf

[55] Schwela, Dieter, and Gary Haq. *Transport and Environment in Sub-Saharan Africa*. Stockholm Environment Institute, 2013, www.jstor.org/stable/resrep00434 . Accessed 28 Feb. 2021.

[56] https://ccacoalition.org/en/news/west-african-ministers-adopt-cleaner-fuels-and-vehicles-standards

[57] https://www.ecolex.org/details/legislation/decret-no-2001-185prespmmee-portant-fixation-des-normes-de-rejets-de-polluants-dans-lair-leau-et-le-sol-lex-faoc026794/

Farquharson simulated converting the current motorcycle fleet in Kigali from conventional to electric lithium ion-powered ones and noted that conventional motorcycles produce up to 5.2 times the CO_2 an electric motorcycle would cause the electric grid to generate over a year and emit $PM_{2.5}$ at least 40 times more than the electric alternatives.[58] Most electric vehicle batteries are guaranteed to have a longevity of approximately 160,000 kms or 8-10 years. The spent batteries can be recycled; these are a valuable secondary source of strategic elements and critical materials for key components in electric-vehicle manufacture.[59]

Lithium-ion powered motor vehicles drastically decrease CO_2 & $PM_{2.5}$ emissions.

Fossil fuel use for power generation

Although a large bulk of electricity is still generated using fossil fuel, there is an increasing trend of hydroelectric generation in SSA (especially in *Mozambique* and *DRC* among the partner countries; with Mozambique generating bulk of hydroelectricity in SSA); this is a very promising source of cleaner energy.[60] However, more than 50% of the SSA population[61] and more than 80% of those in rural areas still do not have access to electricity while most of the rest have erratic/interrupted supplies; for instance, manufacturers experience an average of 56 days/year of shutdowns because of power outages.[62] Thus, there is widespread use of fossil fuel-powered electricity generators that often serve as the primary and/or exclusive source of electricity in business establishments and households. Fossil fuel-powered electricity generators significantly contribute to air pollution, emitting fine particulate matter, carbon dioxide, nitrous oxides and sulphur oxide, among others[63]; extensive, unabated use of these electric generators only leads to increased fossil fuel consumption and increased air emissions.[64]

Increasing the reliability and availability of "clean" / eco-friendly electricity supply will substantially decrease emissions and lead to economic savings. Aside from hydroelectric energy, there is great potential for wind, solar and geothermal energy. Projections demonstrate that even replacing only 50% of present electricity generation with sustainable means (from hydrothermal, wind and solar energy) could already decrease CO_2 emissions by 310 mega-tonnes.[65]

Estimates for sustainable electricity generation potential in SSA, per year:

- *Up to 1,300 gigawatts from wind.*
  https://gwec.net/africa-wind-energy-handbook/
- *Approximately 660,000 terawatts from solar photovoltaic system*
  https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf
- *Up to 350 gigawatts from hydroelectric energy & 15 gigawatts from geothermal energy.*
  https://www.dlapiper.com/en/uk/insights/publications/2019/11/africa-connected-issue-3/the-rise-of-alternative-energy-sources-in-africa/

[58] Farquharson DT, Sustainable Energy Transitions in sub-Saharan Africa: Impacts on Air Quality, Economics, and Fuel Consumption, 2019. Available from: https://kilthub.cmu.edu/articles/thesis/Sustainable_Energy_Transitions_in_sub-Saharan_Africa_Impacts_on_Air_Quality_Economics_and_Fuel_Consumption/9250325/ 1

[59] Harper G, Sommerville R, Kendrick E, et al. Recycling lithium-ion batteries from electric vehicles. Nature 2019; 575: 75-86.

[60] https://www.eia.gov/todayinenergy/detail.php?id=37153

[61] https://www.iea.org/reports/africa-energy-outlook-2019

[62] https://www.un.org/africarenewal/web-features/africa's-bumpy-road-sustainable-energy

[63] http://documents1.worldbank.org/curated/en/640791573016682618/pdf/Summary.pdf

[64] Farquharson DT, Jaramillo P, Samaras C. Sustainability implications of electricity outages in sub-Saharan Africa. Nature Sustainability. 2018; 1: 589-597. Available from: https://www.nature.com/articles/s41893-018-0151-8?WT.feed_name=subjects_environmental-impact

[65] International Renewable Energy Agency (IRENA). Africa 2030: Roadmap for a Renewable Energy Future. 2015. IRENA, Abu Dhabi. Available from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_Africa_2030_REmap_2015_low-res.pdf

There is also a potential for tapping solid waste to generate electricity, solving two problems – waste management and electricity generation – at the same time.[66] This has already been implemented in Ethiopia and is being developed in Kenya.[67]

Production of liquid biofuels from food waste and agricultural residues has very high potential as well; however, there is limited technological readiness for production.[68]

Regarding use of biomass fuels, the 'Africa Biogas Partnership Programme' (ABPP) is an interesting programme developed in *Burkina Faso,* Ethiopia, Kenya, Tanzania and *Uganda* with support from the international development organization SNV (*Stichting Nederlandse Vrijwilligers*). This public-private partnership engagement aims to provide access to energy services through the installation of biogas digesters in partnership with local enterprises, NGOs, and governments[69].

Energy Private Developers (EPD) Association is a registered professional association in Rwanda, regrouping 32 private companies operating for the development of the energy sector (solar home system, mini-grids, hydropower, biomass, methane gas, clean cooking technologies, other). EPD works in collaboration with the Government of Rwanda and has a vision of all homes in Rwanda having access to modern energy in an environment through which the private sector can innovate, grow and thrive. EPD focuses on the advocacy of its members, encouraging collaboration and partnership.

Some of their activities, for the past years, included advocating for the new ministerial guidelines which were put in place by the Government of Rwanda. The objectives of these guidelines are to clearly describe the minimum requirements to be fulfilled by a stand-alone solar power system to ensure good quality and reliable services to the beneficiaries. They also contributed to the introduction of taxation policy on spare parts for solar home system, mini-grids, hydro and biomass.

Together with the East African Community and the Government of Rwanda, they organized the EAC Policy Public Private Dialogue focused on Renewable Energy policy and standards of renewable energy equipment on the EAC market. This Policy Dialogue was supported by Bfz (Germany), Enabel, and United Nations Industrial Development Organization (UNIDO). EPD is also participating in the Pro Poor Results-based Financing programme for solar lighting, supported by DFID and USAID.

Each year they organise a conference known as 'Renewable Energy for Sustainable Growth (RE4SG)'. In 2019, the main theme was 'Achieving Universal Access' where reenergizing agriculture through solar technologies and E-mobility were discussed among other issues. Solar power in agriculture will reduce the operational cost, particularly of irrigation, post-harvest and livestock value chains, especially for milk cooling. To improve the quality of air, reduce congestion and provide clean, reliable and affordable energy to their growing populations, they foresee a shift from traditional fossil fuel combustion engines to electric-powered engines. Electric cars and motor vehicles fully powered by batteries, fuel cells or complementing internal combustion engines could offer efficiency in the transport sector.

This partnership between private investors and public institutions demonstrates that it is possible to join forces to a common goal safeguarding public interest and social priorities.

- Energy Private Developers Association (2020) EPD Annual Performance Report 2019 ; 2020 Half-Year Report. ; EDP Conference Report 3rd Edition of Renewable Energy for Sustainable Growth. EPD, Kigali, Rwanda. ; https://www.epdrwanda.com/

[66] Mwangomo EA. Potential of Waste to Energy in African Urban Areas. Adv Recycling Waste Manag. 2018; 3: 162.
[67] https://www.ifri.org/en/publications/etudes-de-lifri/waste-management-and-electricity-generation-africa-developing-waste
[68] IRENA. Biofuel Potential in Sub-Saharan Africa: Raising food yields, reducing food waste and utilising residues. 2017. IRENA, Abu Dhabi. Available from: https://www.irena.org/ -/media/Files/IRENA/Agency/Publication/2017/Nov/IRENA_Biofuel_potential_sub-Saharan_Africa_2017.pdf
[69] https://snv.org/project/africa-biogas-partnership-programme-abpp

Waste Management

The African Union has set an ambitious aspiration that cities will be recycling at least 50% of the waste they generate[70], but waste management is a challenge in all partner countries. Data from UNEP (2018) reports 125 million tonnes of municipal solid waste (MSW) was generated in sub-Saharan Africa in 2012, which is expected to double by 2025. The average MSW collection rate is only 55%. More than 90% of waste generated in Africa is disposed at uncontrolled dumpsites and landfills, often with associated open burning. On average, 13% of MSW is plastic and 57% is organic waste. Recycling has emerged across Africa, driven more by poverty, unemployment and socio-economic need than by public and private sector design. An estimated 70-80% of the MSW generated is recyclable, yet only 4% of MSW is currently recycled, creating increased risk of disease, flooding and environmental pollution, generation of greenhouse gases, and increasing marine plastic litter. SSA is a dumping ground for end-of-life goods, such as electronic waste, often originating from developed countries. This landscape impacts on human health and the environment.[71]

Facing this challenging context, the EAC Secretariat is working to harmonise effluent discharge standards to help control water pollution and is developing the EAC Electronic Waste Management Framework and Management of Plastic and Plastic Waste Disposal.[72] A ban on plastic bags is now in effect in *Rwanda,* Kenya, Tanzania and Zambia.[73]

In Rwanda, it has been illegal to import, produce, use or sell plastic bags and plastic packaging since 2008.

Furthermore, some partner countries have developed a range of interventions. *Benin* launched the *Household Solid Waste Management Modernization Project* in the Grand Nokoué, created by the Government of Benin as part of the flagship projects of the Government's Action Program (PAG 2016-2021). The first phase of the project started in April 2020 and will allow the collection of waste in five large cities of Grand Nokoué (Cotonou, Porto-Novo, Ouidah, Abomey-Calavi and Sèmè-Kpodji).[74] While Conakry (*Guinea*) battles with waste incineration,[75] the SANITA Clean Cities Programme, funded by the European Union was implemented by Enabel. The aim of the programme is to professionalize the solid waste management sector in Conakry and the city of Kindia through improving door-to-door collection, sorting and recycling of waste, development of roads and the cleaning of gutters to ensure better evacuation of rainwater.[76]

The Sanita Clean City in Guinea, financed by the European Union and implemented by Enabel in the cities of Conakry and Kindia in collaboration with the Agence Nationale de l'Assainissement et la Salubrité Publique (ANASP) and the Direction de l'Aménagementdu Territoireet de l'Urbanisme (DATU) is aimed *towards the professionalization of the waste management sector in order to set up an efficient and sustainable management system. The project strategies include: sensitization, organization and effective reinforcement of key actors; improved transit with opening up of priority neighbourhoods (roads as well as drainage); improved sorting, recycling and recovery (e.g., creation of resources from waste, plastics, metals, aluminium; organic matter sorting for anaerobic digestion and compost reducing methane emissions; and reducing mechanization and use of fossil fuels.*[76]

[70] https://au.int/en/agenda2063/outcomes
[71] United Nations Environment Programme (2018) Africa Waste Management Outlook. UNEP, Nairobi, Kenya Available from: https://wedocs.unep.org/handle/20.500.11822/25514
[72] East African Community. Pollution and waste management. Available from: https://www.eac.int/health/115-sector/environment-natural-resources-management/pollution-and-waste-management
[73] United Nations Environment Programme. Plastic bag bans can help reduce toxic fumes. Available from: https://www.unep.org/news-and-stories/story/plastic-bag-bans-can-help-reduce-toxic-fumes
[74] https://www.afrik21.africa/en/benin-solid-waste-management-project-finally-starts-in-grand-nokoue
[75] Impact de l'incinération des déchets sur la qualité de l'air en Guinée https://www.youtube.com/watch?v=Y4rFeNj965M&feature=emb_title
[76] https://www.facebook.com/sanitavillespropresGuinee/

Some NGOs (ECODEV and GRET) have started advocacy committees for funding waste management in secondary cities.[77,78] In *Rwanda*, the Rural Development Inter-diocesan Service (RDIS) organization is currently implementing the '*Waste Management for Environmental Safeguard*' project. The beneficiaries of the project are Church's training centres, guest houses, schools and health centres. Waste bins, policies and training on waste management are provided.[79]
The World Bank approved in February 2020 the *Senegal Municipal Solid Waste Management Project* which aims to strengthen the governance and services of solid waste management in selected municipalities.[80]
In Uganda, over 100 formally registered companies and at least 40 NGOs and CBOs are involved in solid waste management.[81] Among these, Plastics Recycling Industries (PRI), an initiative of Coca-Cola Beverages Africa, is targeting the collection, segregation and recycling of plastic waste, processing approximately 3,600 tons of plastic waste every year. PRI contracts 120 community-based organisations and small enterprises to collect plastic waste, which it then recycles at its capital plant.[82]

Industrial and occupational pollutants and hazards

Harmful mining and related industrial activities have been observed in some of the partner countries. For instance, for one tonne of aluminium produced in Guinea, three tonnes of waste are produced around the bauxite mines which end up largely in the form of red sludge loaded with heavy metals, the consequences of which can be disastrous[83]. Local Guinean residents have likewise been helpless in the face of health and environmental repercussions from smoke released from cement factories for decades.[84] Emissions from copper, cobalt and gold mining in DRC are responsible for alarming levels of air pollution according to the WHO.[85]

Exposure to fumes, irritants and dust emitted by industries and in the workplace may be associated with reduced lung function, whether manifesting as restrictive lung disease (e.g., exposure to silica dust) or obstructive lung disease (e.g., working in cotton mills).[86] In DRC, Mbelambela et al.[87] demonstrated that certain tasks related to exposure to cement dust is associated with the higher prevalence of COPD and respiratory symptoms.

It should be accepted that some essential occupations will always pose some degree of exposure to harmful substances, and that, more importantly, all means to control

[77] République Islamique de Mauritanie, Ministère de l'Environnement et du Développement Durable (2017) Stratégie Nationale de l'Environnement et du Développement Durable et son Plan d'action pour la période 2017-2021. Nouakchott, Mauritanie. http://extwprlegs1.fao.org/docs/pdf/Mau175844.pdf ; Sy I, Koita M., Traoré D. et al (2011) Vulnérabilité sanitaire et environnementale dans les quartiers défavorisés de Nouakchott (Mauritanie): analyse des conditions d'émergence et de développement de maladies en milieu urbain sahélien. VertigO, *Revue électronique en sciences de l'environnement* [En ligne], Vol 11 Nr 2 https://www.erudit.org/en/journals/vertigo/2011-v11-n2-vertigo0119/1009364ar/ ; GIZ (2014) Rapport sur la gestion des déchets solides en Mauritanie, SWEEPnet. Eschborn, Germany. https://www.resource-recovery.net/sites/default/files/mauritanis_ra_fr_web.pdf

[78] *Eco-development (ECODEV)* is an association under Mauritanian law committed to development. It is involved in any initiative aimed at improving the living conditions of the populations. The association also contributes to the protection of natural resources and the environment. https://www.devex.com/organizations/eco-development-ecodev-140709
Groupe de Recherches et d'Echanges Technologiques (GRET) is an international development NGO governed by French law. Since 1976 it has been working to provide sustainable, innovative responses to the challenges of poverty and inequalities. https://www.gret.org/

[79] http://www.rdis.org.rw/waste-management

[80] http://documents1.worldbank.org/curated/en/201751583719244867/pdf/Senegal-Municipal-Solid-Waste-Management-Project.pdf

[81] Tukahirwa J.T., Mol A.P.J. and Oosterveer P. (2010) Civil society participation in urban sanitation and solid waste management in Uganda. *Local Environment*, 15:1, 1-14, https://doi.org/10.1080/13549830903406032

[82] https://www.facebook.com/PlasticRecyclingIndustries/

[83] https://mrmondialisation.org/guinee-conakry-la-course-a-laluminium-fait-peser-de-graves-menaces-sur-lenvironnement/

[84] https://www.youtube.com/watch?v=Tf0KGvo-kB4

[85] https://www.congodurable.net/2017/05/25/linquietante-pollution-de-lair-en-rdc/

[86] Burney et al., 2015. Op cit page 2.

[87] Mbelambela EP, Eitoku M, Muchanga SMJ, et al. Prevalence of chronic obstructive pulmonary disease (COPD) among Congolese cement workers exposed to cement dust, in Kongo Central Province. Environ Sci Pollut Res Int. 2018 Dec;25(35):35074-35083.

exposures should be instituted. However, technical and technological means to control pollution emissions and improve the work environment in the partner countries are lacking; and education and communication are mainly supported by (international) technical and financial partners.[88] In Mozambique, coal mining in Tete has long been a serious hazard for the population but the Mozambican government only very recently recognized the environmental pollution caused by the Moatize mines.[89]

Technical and technological means to control pollution emissions and improve the work environment are lacking in SSA.

Another significant occupational risk to respiratory health is *exposure to pesticides*. The intensive use of phytosanitary products in agriculture in the cultivation of cotton (Benin and Burkina Faso), tea and coffee (Burundi, Rwanda, and Uganda), rice (Senegal), market garden products (all partner countries), among others, pollute terrestrial ecosystems by the widespread presence of pesticide residues and are directly harmful to respiratory health of those exposed. In a context where the level of education and training of producers is low, poor phytosanitary practices have been highlighted, such as: the use of prohibited molecules; purchase of products on the black market or repackaged without instructions; storage of pesticides at home without any protection measures; systematic, excessive and/or inappropriate applications; handling and application without use of any personal protective equipment; failure to respect the pre-harvest period; re-utilisation of empty containers at home or for the transport of water or cooking oil, etc. A number of studies have demonstrated significant associations of exposure to pesticides with respiratory symptoms (cough, difficulty in breathing), impaired respiratory function, and bronchial asthma and COPD.[90]

Use of pesticides is an occupational risk that has received little to no attention in a number of LMICs, not only in sub-Saharan Africa.
Pesticide use affects the applicator and exposes people within the vicinity to the aerosol.
Pesticides contaminate the soil, water and other vegetations.
Re-use of pesticide containers is also a problem especially as it is at times used for storage of food and water.

Dust- and sandstorms

A total of 60% of Saharan dust particles are blown across the Sahel and sub-Sahel countries including the partner countries Benin, Burkina Faso, Mauritania, Niger and Senegal (Zhang et al 2016),[91] which affects air quality and respiratory health.[92]

Dust- and sandstorms directly cause and worsen a gamut of respiratory conditions that includes bronchial asthma, COPD, restrictive lung disease (e.g., silicosis), interstitial

[88] https://www.mediacongo.net/article-actualite-50028_pollution_kinshasa_compte_parmi_les_villes_ou_la_qualite_de_l_air_pose_probleme.html
[89] https://www.portaldogoverno.gov.mz/por/Imprensa/Noticias/Mocambique-Tete-Governo-reconhece-poluicao-ambiental-proveniente-das-minas-de-Moatize
[90] Mamane A, Baldi I, Tessier JF, et al. Occupational exposure to pesticides and respiratory health. European Respiratory Review 2015 24: 306-319
[91] Zhang X, Zhao L, Tong DQ, et al. *A Systematic Review of Global Desert Dust and Associated Human Health Effects*. Atmosphere. 2016; 7: 158.
[92] De Longueville F. et al. (2010) What do we know about effects of desert dust on air quality and human health in West Africa compared to other regions? *Science of the Total Environment*, 409:1, 1-8; Lindén J. et al (2012) Urban Climate and Air pollution in Ouagadougou, Burkina Faso - An overview of results from five field studies. University of Gothenburg, Sweden. https://core.ac.uk/download/pdf/18407815.pdf ; Ozer, P. et al. (2007) Estimation of air quality degradation due to Saharan dust at Nouakchott, Mauritania, from horizontal visibility data. *Water Air Soil Pollut* 178, 79-87 https://doi.org/10.1007/s11270-006-9152-8; Ozer P. (2008) Impact of dust processes on air quality in Niamey, Niger, and consequences on human health https://orbi.uliege.be/bitstream/2268/16149/1/Ozer_BookDesertification_2008.pdf ; Touré, N. O. et al. (2019). Observed and modelled seasonal air quality and respiratory health in Senegal during 2015 and 2016. *GeoHealth*, 3, 423–390. https://doi.org/10.1029/423–390.3

lung disease, and lower respiratory tract infections, aside from cardiovascular conditions.[93] A blog from the American Thoracic society indicates that every year millions of tons of dust are aerosolized off the coast of sub-Saharan Africa and this has been increasing over time due to climate change.[94]

Effects of bad air on health and well-being

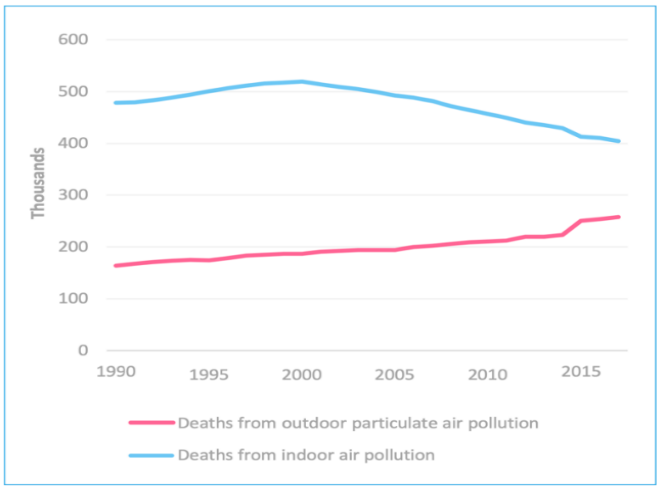
During the celebrations of the World Environment Day in June 2019, a member of the *Rwanda*n MoH said that "*one out of four people is affected by respiratory diseases every year. They are mostly caused by cooking with firewood, charcoal, petrol, fuel and ambient air pollution.*"[95] Solid fuel use is a newly identified predictor of chronic lung disease-related impairment and typical for low-resource settings[96, 97] such as that of the partner countries.

Exposure to both outdoor and indoor air pollution affects man throughout the life-course and starts from the womb. During pregnancy, exposure of an expectant mother to air pollution may cause intrauterine foetal deaths, preterm delivery and low birth weight; and can contribute to poor lung development and disturbed development of the immune system of a foetus.[98] It should be noted that development of the lungs and the immune system continues after birth until around six years of age, and exposure to air pollution negatively influences the said developments.[99] Older children are likewise affected; a prospective study involving children aged 10-18 years demonstrated that lung impairment characterised by obstruction to air flow was significantly associated with exposure to nitrogen dioxide, acid vapor, particulate matter with an aerodynamic diameter of less than 2.5 μm ($PM_{2.5}$), and elemental carbon.[100] Air pollution does not only contribute to poor lung development and damage to the adult lungs that could lead to bronchial asthma and COPD; both short- and long-term exposure would also trigger exacerbations in both conditions in all ages, thereby increasing morbidity and mortality. Exposure to air pollution has also been demonstrated to be directly associated with cardiovascular diseases,[101] cardiovascular events[102] and lung cancer.[103]

Figure 5 is a graph from Unicef[104] (2019) showing the absolute number of deaths attributed to ambient (outdoor) air pollution and to household pollution from cooking and heating over a 27-year period (1990-2017). The figure shows a seeming decline in the number of deaths from indoor air pollution and increasing numbers of deaths from outdoor particulate air pollution through the years. However, it is unsure whether this increase in deaths is relative to the increase in the urban population or to "worsening" outdoor air quality and we can only surmise that some interventions on indoor air pollution are probably working, or that the decreasing number of deaths is an effect of decreasing rural populations due to internal migration. However, the numbers of deaths remain alarming.

[93] https://www.thoracic.org/patients/patient-resources/resources/sand-and-dust-storms.pdf
[94] https://www.lung.org/blog/dust-storms-and-lung-health
[95] https://www.newtimes.co.rw/news/over-three-million-suffer-respiratory-diseases-annually-report
[96] Brakema et al., 2019. Op cit page 2.
[97] van Gemert F, Kirenga B, Chavannes N, et al. Prevalence of chronic obstructive pulmonary disease and associated risk factors in Uganda (FRESH AIR Uganda): a prospective cross-sectional observational study.Lancet Glob Health. 2015 Jan;3(1):e44-51.
[98] Korten I, Ramsey K, Lantzy P. Air pollution during pregnancy and lung development in the child. Paediatr Respir Rev. 2017 Jan;21:38-46
[99] Schwartz J. Air pollution and children's health. Pediatrics. Apr 2004; 113 (Supplement 3): 1037-1043
[100] Gauderman WJ, Avol E, Gilliland F, et al. The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. NEJM. 2004 Sept; 351(11): 1057-1067.
[101] Lee BJ, Kim B, & Lee K. Air Pollution Exposure and Cardiovascular Disease. *Toxicol. Res.* 2014; 30 (2): 71-75.
[102] Franchini M & Manucci PM. Short-term effects of air pollution on cardiovascular diseases: outcomes and mechanisms. J Thromb Haemost 2007; 5: 2169–2174.
[103] Cohen AJ. Outdoor air pollution and lung cancer. Environ Health Perspect. 2000 Aug;108 Suppl 4(Suppl 4):743-50.
[104] Rees N, Wickham A & Choi Y. Silent Suffocation in Africa: Air Pollution is a Growing Menace, Affecting the Poorest Children the Most. UNICEF 2019. Available from: https://www.unicef.org/media/55081/file/Silent_suffocation_in_africa_air_pollution_2019.pdf

Figure 5. Deaths from ambient (outdoor) air pollution and from household pollution, Africa, 1990-2017.



In 2013, the United Nations[105] estimated economic cost of premature deaths from ambient particulate matter pollution to be approximately US$ 215 billion; and that from household air pollution to be approximately US$ 232 billion.

Current actions on air quality in the partner countries

In the partner countries, the problem of urban air pollution is receiving low public attention and is placed low on government agendas. Consequently, public bodies frequently lack legal or political incentives, funds, standards, and policy guidelines to help keep air quality within healthy ranges.[106] Some capital cities (Cotonou, Dakar, Kampala, Kigali, Ouagadougou…) have air quality monitoring networks but these are still insufficient and not properly monitored. The overall limited amount of data, legislation, and country-specific polluting activities in partner countries make it difficult to be fully aware of the health threats that their population faces.

Most partner countries have environmental laws and/or have ratified international environmental agreements such as the United Nations Framework Convention on Climate Change, the Montreal Protocol on Substances that Deplete the Ozone Layer, the Kyoto Protocol on Climate Change, the Paris Climate Agreement, etc. While some countries stopped at this level, others have gone further with national regulations. Such is the case for Benin, Burkina Faso, Rwanda, Senegal and Uganda. Benin[107], Rwanda[108] and Senegal[109] have air quality standards; while Uganda is developing these.[110]

Also, some of these countries are pioneering a number of actions related to air quality:

- *Senegal* created the '*Air Quality Management Centre*' which has a reference laboratory and five fixed air pollution measurement stations spread across the city of Dakar. These fixed stations are supplemented by a mobile laboratory which performs measurements in targeted locations.[111]

[105] Roy R. The cost of air pollution in Africa. 2016. Available from: https://www.un.org/africarenewal/sites/www.un.org.africarenewal/files/The_cost_%20of_air%20pollution_in_%20Africa.pdf

[106] Alvarez C.M., Hourcade R., Lefebvre B. and Pilot E. (2020) A Scoping Review on Air Quality Monitoring, Policy and Health in West African Cities. *Int. J. Environ. Res. Public Health*,17, 9151 https://www.mdpi.com/1660-4601/17/23/9151/htm

[107] https://www.ecolex.org/details/legislation/loi-no-98-030-portant-loi-cadre-sur-lenvironnement-en-republique-du-benin-lex-faoc016685/

[108] http://airqualityandmobility.org/PDFs/ECOWAS2019/Needtolinkwithvehicleemissions.pdf

[109] https://www.ecolex.org/details/legislation/arrete-interministeriel-n-7358-du-5-novembre-2003-fixant-les-conditions-dapplication-de-la-norme-ns-05-062-sur-la-pollution-atmospherique-lex-faoc175486/

[110] https://assets.publishing.service.gov.uk/media/5eb16f3286650c4356562f92/ASAP_-_East_Africa_-_Air_Quality_Briefing_Note_-_Kampala.pdf

[111] http://www.denv.gouv.sn/index.php/air-et-climat/centre-de-gestion-de-la-qualite-de-l-air-cgqa

- *Rwanda* put in place the '*Environment Management Authority* (REMA)' under supervision of the Ministry of Environment with the legal mandate for national environmental protection, conservation, promotion and overall management, including advisory functions to the government on all matters pertinent to the environment and climate change[112]. It also created the *Rwanda Standards Board* (RSB) to undertake all activities pertaining to the development of standards, conformity assessment and meteorology services in the country.[113]
- Based in Cotonou, *Benin*, the Project AIRQALI-4-ASMAFRI '*Air quality and quality of life for asthmatic children in Africa*', supported by the Institute of Research for Development, France, examines the relationship between air pollution and asthma in urban areas of West Africa, where different types of sources of air pollution (anthropogenic and natural) are combined.[114]

The *East African Community* (EAC) Secretariat[115] is working on the implementation of the provisions of the Eastern African Framework Agreement on Air Pollution, and towards strengthening the capacity of EAC partner States in enforcement of pollution control laws and establishing pollution monitoring systems.

There are also *regional initiatives* addressing air pollution that go beyond each country's frontiers and are much influenced by transnational and transcontinental trade, travel and migration:

- In 2008 the *Eastern Africa Regional Framework Agreement on Air Pollution* (known as the "*Nairobi Agreement*") brought together 11 countries, with *Burundi, DR of the Congo, Rwanda* and *Uganda* among Enabel partner countries. The Nairobi Agreement intended to develop actionable targets to address air pollution in the following key areas: transport, industry and mining, energy, waste, vegetation fires, indoor air pollution, urban planning and management, and regional and national environmental governance.[116] The EAC is monitoring progress on the Nairobi Agreement.
- An *African Air Quality and Climate Laboratory* has been installed at the University of Rwanda College of Science and Technology, and it is equipped with the 'Medusa' system, which measures more than 50 gases that deplete the ozone layer. This project is being implemented by the Ministries of Education and Environment and the Rwanda Meteorological Agency in partnership with the Massachusetts Institute of Technology (MIT), USA.[117]
- The *African Centre for Clean Air* (ACCA), based in Kampala is a research and policy centre which employs a multidisciplinary approach to develop African-based capacity to tackle the causes of air pollution, foster advocacy skills, and provide evidence for policy changes to protect health. [118] They are conducting studies on '*Measuring Air Quality for Advocacy in Africa*' across 15 sites in 9 countries, including *Benin, Burkina Faso* and *Uganda*.[119] The study on '*Maternal air pollutant exposure and the lung function of their babies in Uganda*' is a collaboration between Liverpool School of Tropical Medicine and Makerere University Lung Institute (MLI), measuring household and ambient air pollution and personal exposure.[120] Lately, they have been measuring the '*Effect of cooking*

[112] https://www.rema.gov.rw/
[113] https://www.rsb.gov.rw/
[114] https://www.ird.fr/lancement-du-projet-airqali-4-asmafri-qualite-de-lair-et-asthme-chez-les-adolescents-au-benin
[115] https://www.eac.int/health/115-sector/environment-natural-resources-management/pollution-and-waste-management
[116] See reference to this Agreement at *page 37 of the 'UN First report on the protection of the atmosphere'*, International Law Commission, 66th session, Geneva, 5 May-6 June and 7 July-8 August 2014, Prepared by Mr. Shinya Murase, Special Rapporteur at https://undocs.org/pdf?symbol=en/A/CN.4/667
[117] https://www.newtimes.co.rw/news/rwanda-launches-centre-measure-global-warming-gases
[118] http://africancentreforcleanair.org/
[119] http://africancentreforcleanair.org/measuring-air-quality-for-advocacy-in-africa-ma3/
[120] http://africancentreforcleanair.org/maternal-air-pollutant-exposure-and-the-lung-function-of-their-babies-in-uganda/

behaviour on exposure to household air pollution from different cooking fuels' in Ethiopia, Nigeria and *Uganda*, assessing how the cooking behaviour among primary cooks using different cooking fuel types determines the level of personal exposure to $PM_{2.5}$ and CO to the cooks and level of concentrations of these pollutants in kitchens.[121]

- The *African Clean Cities Platform* (ACCP) concentrates on education and sharing knowledge with the aim that by 2030, African countries realize clean and healthy cities and achieve the SDGs on waste management. The Platform presently covers 65 cities in 37 countries in Africa, among which are *Benin, Burkina Faso, DR of the Congo, Guinea, Mozambique, Niger* and *Uganda*[122]
- *Chair in eco-health on urban air pollution and non-communicable respiratory diseases (West Africa)*. The Canadian International Development Research Centre has contributed to the emergence of the West and Central African Ecohealth Community of Practice (COPES-AOC) and to the institutionalization of ecosystem approaches to health in several institutions of higher education and research, materialized by the recent creation of an Interuniversity Doctoral Program (IDP) in public health integrating health and environment adopted by five universities in four West African countries (*Benin, Burkina Faso*, Côte d'Ivoire and *Senegal*).

iii. Lack of adequate indoor ventilation

Traditional African houses are wattle-daub or mud-block constructions built on the ground, with poor ventilation. Most kitchens lack chimneys; however, outdoor cooking as an alternative is not always acceptable.[123]

Poor housekeeping practices, non-installation of necessary exhaust units and absence of ventilation in the workplace are common.

In the absence of adequate ventilation, smoke from burning biomass fuels and indoor cigarette smoking, dusts and fumes generated in the workplace, etc., would not be effectively dissipated and would hang like a cloak of miasma of noxious gases and particulate matter to be continuously breathed in and absorbed by people whilst inside these structures.

Although marked improvements in housing in SSA have been noted in terms of improved water and sanitation, sufficient living area and durable construction, this only represents less than a quarter of such housing needs (improved housing of 11% in 2000, increasing to 23% in 2015).[124]

Occupational safety and health rank low in the political agenda in SSA.

Considering the occupational pollution and hazards presented in pages 21-22 and the infrastructural deficiencies in workplaces in Africa, it is quite unfortunate that working conditions, occupational safety, health and hygiene only play a minor role in the Healthy City project in SSA; more than that, it ranks low on the political agenda.[125] No ongoing actions have been identified in the partner African countries, and the

[121] http://africancentreforcleanair.org/effect-of-cooking-behaviour-on-exposure-to-household-air-pollution-from-different-cooking-fuels/

[122] It was established in April 2017 with the initiative of the Ministry of the Environment of Japan, the Japan International Cooperation Agency (JICA), the United Nations Environment Program (UNEP), the United Nations Human Settlement Plan (UN-Habitat) and City of Yokohama (Japan) https://africancleancities.org/

[123] van Gemert F, Chavannes N, Nabadda N, Luzige S, Kirenga B, Eggermont C, de Jong C, van der Molen T. Impact of chronic respiratory symptoms in a rural area of sub-Saharan Africa: an in-depth qualitative study in the Masindi district of Uganda. Prim Care Respir J. 2013 Sep;22(3):300-5

[124] Tusting LS, Bisanzio D, Alabaster G, et al. Mapping changes in housing in sub-Saharan Africa from 2000 to 2015. Nature. 568, pages391–394(2019)

[125] Swuste P & Eijkemans G. Occupational Safety, Health, and Hygiene in the Urban Informal Sector of Sub-Saharan Africa: An Application of the Prevention and Control Exchange (PACE) Program to the Informal-sector Workers in Healthy City Projects. International Journal on Occupational and Environmental Health. 2002; 8:2; 113-118

challenges of provision of decent working conditions including improving workplace safety and health remain.

iv. <u>Poor access to healthy food</u>

There is growing evidence on the protective effects on lung function and respiratory symptoms of the antioxidant vitamins A, C and E, omega-3 fatty acids, and magnesium; on the other hand, sodium, omega-6 fatty acids and trans-fats may be potentially harmful to respiratory functioning.[126]

In the early years, micronutrient deficiency can retard lung development, affecting both its size and function.

However, food insecurity is quite widespread in SSA; diet mostly consists of carbohydrate-rich cereals and root crops with limited access to (animal-source) proteins and nutrient-rich fruits and vegetables, and with low diet diversity.[127]

v. <u>Poor access to healthcare and medications</u>

Access to healthcare is influenced from the demand-side and the supply-side.

Factors that may influence healthcare seeking on the side of a population are rooted in perceptions, beliefs, personal and social values, culture, the abilities to reach and pay for the needed healthcare, and adequate health literacy to recognise that healthcare is needed, should be sought and that the person should do the things needed to be done to care for the self.[128]

In a qualitative study conducted in Uganda[129], it was found that chronic cough and shortness of breath are a stigma and considered contagious. However, people refrained from seeking medical care unless there is rapid worsening of symptoms. This could be due to the low trust in health centres, especially in the care for chronic respiratory conditions: people deemed that the health centres do not have any possibility to treat them unless they get a TB diagnosis.

> *In Masindi District, Uganda, people are disappointed if they do not get a TB diagnosis because the health services would not have anything to offer for treatment of their cough.*
> *- Van Gemert et al, 2013.*

On the supply side, Levesque et al. (2013) propose that health services and/or providers should have the following characteristics: approachability through outreach, information provision, and transparency; acceptability as regards professional values and culture, norms, and gender; geographic accessibility and reasonable hours of opening; affordability; having the appropriate care quality with adequate services including diagnostics and treatment modalities; and offering proper coordination and continuity of care.

Current actions on chronic care

As is the case in most LMICs worldwide, the African partner countries struggle with the double burden of disease and still pay more attention to infectious diseases over NCDs. Furthermore, a number of ongoing health programs are externally funded, and activities are generally donor-dictated.

---

[126] Smit, HA. Chronic obstructive pulmonary disease, asthma and protective effects of food intake: from hypothesis to evidence? *Respir Res* 2001, 2:261–264.

[127] Fanzo J. The Nutritional Challenge in Sub-Saharan Africa 2012. Available from https://www.africa.undp.org/content/rba/en/home/library/working-papers/nutrition-challenge.html

[128] Levesque JF, Harris MF, Russel G. Patient-centred access to health care: conceptualizing acces at the interface of health systems and populations. *International Journal for Equity in* Health *2013;*12:18. Available from: http://www.equityhealthj.com/content/12/1/18 .

[129] Van Gemert et al., 2013. Op cit page 19.

All partner countries have *National Health Policies* (NHP) and regular *Health Sector Development Plans* (HSDP) where NCDs are mentioned as priority problem and area of action. However, CRDs are not yet in the forefront among the NCDs prioritized by almost all of the partner countries; only Niger, Rwanda and Uganda mention CRDs in their HSDP. Burundi, Rwanda and Uganda have set up inter-ministerial committees responsible of NCD response for streamlining NCDs interventions across all actors.

Rwanda's HSDP has an innovative crosscutting approach involving "synergistic multi-sectoral strategies for mainstreaming NCDs" in various sectors other than health, including strategies "to regulate and implement policy/laws for air/indoor pollution and other environmental factors related to NCD."

All of the partner countries also developed *NCD Integrated Strategic Plans*[130] but only six out of 11 explicitly included CRD:

- *Benin* planned the promotion of the fight against CRD (asthma and chronic obstructive pulmonary disease (COPD) through prevention and access to equitable services.[131]
- *Guinea* refers to the lack of standardized CRD care at the different levels of service and highlights that only hospitals are capable of attending to CRD cases. The Guinean Plan refers to NCD as a whole and mentions the development of activities following the WHO Package of Essential NCD Interventions (WHO-PEN[132]) guidelines which include CRD[133].
- *Mauritania* recognises the management of CRD is insufficient and only 23% of its health services are able to take care of them adequately. In their Plan, they consider to strengthen the fight against risk factors such as tobacco consumption and indoor air pollution, and the prevention of occupational respiratory diseases (exposure to silicosis, etc.)[134]
- *Mozambique* focused on asthma, including access to treatment and medicines for the exacerbation and inter-critical periods[135].
- In spite of recognising that CRD - both asthma and COPD - are "clearly progressing", *Niger* does not plan specific actions besides tobacco control; however, there are initiatives taken by the National NCD Programme such as the elaboration of an algorithm for asthma management. [136, 137]

---

[130] The 67th session of the WHO Regional Committee for Africa (28 Aug-1 Sept 2017) adopted the Regional Framework for the Integration of Essential NCD Control Services into PHC providers. WHO has worked with the West African Health Organization (WAHO) to train managers of NCD programmes in the use of the WHO-PEN *(see below)*

[131] République du Bénin, Ministère de la Santé (n/d) Plan Stratégique Intégré de Lutte contre les Maladies Non Transmissibles 2014-2018. Cotonou, Bénin https://www.iccp-portal.org/system/files/plans/Benin%20Plan_strategique_integre_lutte_contre_maladies_non_transmissibles_2014-2018.pdf

[132] WHO (2010) Package of Essential Non-communicable (PEN) Diseases Interventions for Primary Health Care in Low-Resource Settings. Geneva, Switzerland. https://apps.who.int/iris/bitstream/handle/10665/44260/9789241598996_eng.pdf?sequence=1 *Note that there is an updated version of 2020:* https://apps.who.int/iris/bitstream/handle/10665/44260/9789241598996_eng.pdf?sequence=1

[133] République de Guinée, Ministère de la Santé et de l'Hygiène Publique (2010) Programme National Intégré de Prévention et de Contrôle des Maladies Non Transmissibles (PNIPCMNT). Conakry, Guinée. https://www.iccp-portal.org/system/files/plans/GIN_B3_PROGRAMME%20NATIONAL%20MNT%20GUINEE%202011-15.pdf

[134] République Islamique de Mauritanie, Ministère de la Santé (2017) Plan Stratégique National intégré et multisectoriel de prévention et de lutte contre les Maladies Non Transmissibles 2018-2022, Nouakchott, Mauritanie https://extranet.who.int/nutrition/gina/sites/default/filesstore/MRT%202018%20Plan%20MNT.pdf

[135] República de Moçambique, Ministério da Saúde (s/d) Plano Estratégico Nacional de Prevenção e Controle das Doenças não transmissiveis para o periodo 2008-2014. Maputo, Moçambique. https://www.iccp-portal.org/system/files/plans/MOZ_B3_Plano%20Estrat%C3%A9gico%20de%20Prevencao%20e%20Controlo%20das%20Doen%C3%A7as%20N%C3%A3o%20Transmiss%C3%ADveis.pdf *More recent document not available on the Internet.*

[136] République du Niger, Ministère de la Santé Publique (2012) Plan stratégique national intégré de prévention et de lutte contre les maladies chroniques non transmissibles. Niamey, Niger https://www.iccp-portal.org/system/files/plans/NER_B3_Plan Stratégique PNLMNT Niger.pdf *More recent document not available on the Internet.*

[137] https://www.sante.gouvne.org/projets-et-programmes/programme-national-de-lutte-contre-les-maladies-non-transmissibles/

- *Rwanda* foresees improved access to quality care along with availability, readiness and quality of NCD services including CRD.[138]

Almost all of the partner countries do not have explicit plans in place to address healthcare demands for CRDs.
Availability of services, equipment and medications varies, but mostly on the low side if not wholly absent.

In early 2010, the WHO developed the Service Availability and Readiness Assessment (SARA) survey to assess the readiness of health facilities to provide general services as well as services related to 20 health programmes, including CRDs. Availability of services offering care and management of CRD varies greatly in partner countries[139], both by the level of health care provided and by the ownership of the health structure.

General availability of CRD services ranges from 6% in Guinea to 98% in Senegal but it is very important to note that this considered not only the capacity of managing patients in the health structures but also if providers diagnosed, or prescribed treatment for CRD, which are quite different.

At the level of district hospitals, availability of CRD services ranges from 18% in Guinea to 98% in Uganda. Some countries, such as Burkina Faso, do not provide CRD services in health centres because CRD medications are not delivered to this level of care; or, availability of services itself is quite low, e.g., 35% in Burundi and 9% in Guinea. With regards to the indicators assessed, the percentage of health personnel trained in diagnosis and management of CRD was 2% in Burundi and 43% in Guinea. Peak flow meters are totally absent in DRC and available only in 14% of health facilities in Benin. The availability of specific medications (prednisolone, injectable epinephrine, salbutamol and beclomethasone inhalers, oxygen, and hydrocortisone) is fluctuating, and oxygen availability can be very problematic. (see Table 2, next page).

The following asthma and COPD medications are currently in the 21st WHO *model list of essential medicines (2019)*, which is used as basis for national essential medicines lists:*

- *Combination inhaled corticosteroid + beta-agonists = formoterol + budesonide.*
- *Inhaled corticosteroids = beclomethasone; budesonide*
- *Inhaled anticholinergics = ipratropium; tiotropium*
- *Short acting β-agonist = salbutamol (nebules; inhaler; injection)*
- *Epinephrine (adrenaline) injection*

Currently, long-acting agents ("controllers") belonging to the class of leukotriene modifiers (for asthma) are not included.

*Available from: https://www.who.int/publications/i/item/WHO MVPEMPIAU2019.06

The SARA survey allows a mean score which is used by WHO for country comparability. Mean scores for partner countries are low: 20% for Senegal and Mauritania; 21% for Niger; 24% for Burkina Faso; 26% for Burundi; 27% for Guinea; 30% for Benin and DR of the Congo; and 36% for Uganda. Undoubtedly these mean scores hide crucial realities such as absence of needed medicines and trained personnel.

In the same qualitative study by Van Gemert et al.[140] it was noted that health centres in Uganda sometimes only had a few essential drugs in stock. In the study site (Masindi district), salbutamol tablets were only available at the hospital and inhaled medications for asthma or COPD were not available at all.

[138] Republic of Rwanda, Ministry of Heath, Rwanda Non-communicable Diseases National Strategic Plan July 2014–June 2019, Kigali, Rwanda https://www.iccp-portal.org/system/files/plans/RWA_B3_NCD_NSP_strategic_plan_2014-2019_v12.pdf
[139] WHO SARA surveys available from: Available from: https://www.who.int/healthinfo/systems/sara_reports/en/ .
[140] Van Gemert et al., 2013. Op cit page 19.

vi. Knowledge and education

A lower level of education is associated with poorer lung functioning; furthermore, a faster decline in lung function was noted among women with lower level of education[141]. Level of education is one of the indicators of socio-economic status and lower socio-economic status has been associated with CRDs[142]. However, there are also other risk factors that are related to lower socio-economic status such as poor nutrition, inadequate housing and living conditions, low birth weight and recurrent respiratory infections.

The general population as well as healthcare workers are not well-informed about the risks related to CRDs and the care for bronchial asthma and COPD.

More importantly, many people in Africa including health workers, are not well informed about factors that may affect respiratory health, including the effects of cigarette smoking and use of biomass fuels[143] and the things needed to be done in the care for bronchial asthma and COPD.

b. Psychosocial circumstances

i. Stress

Chronic stress has been associated with poorer pulmonary function elsewhere;[144] and high cortisol and inflammatory biomarker levels due to urban stressors have been linked to lung injury.[145] Although the initial response to stress stimulates the airways to open up (sympathetic response, causing bronchodilation), there is a rebound response that would cause the airways to constrict (parasympathetic rebound, causing bronchoconstriction). This response can either lead to stress-induced asthma or exacerbate pre-existing asthma or COPD. Stress likewise affects the immune system and makes an individual more prone to have respiratory infections.[146]

There was no published information found regarding psychosocial stress and mental well-being as related to CRDs in the partner countries.

ii. Psychosocial dynamics

The gender divide is still pervasive in SSA and, in most countries, patriarchy is very much evident in that the needs and wants of men are prioritized over those of women and children, and men have an (almost) exclusive position of power. Women and girls have culturally defined roles, such as meal preparations, taking care of babies and younger children, etc; while men expect to be the decision-makers and thereby have the inclination to do whatever they wish.

In households where biomass fuel is used, women and girls as well as the babies and younger children they take care of are methodically exposed to the particulate matter and toxic compounds. Men often smoke tobacco wherever and whenever they wish, even within their dwellings, and usually women would not be able to do anything about this.

[141] Tabak C, Spijkerman AMW, Verschuren WMM and Smit HA. Does educational level influence lung function decline (Doetinchem Cohort Study)? Eur Respir J 2009; 34: 940–947.
[142] Hounkpe–Dos Santos BA, Gbary AR, Kpozehouen A & Kassa F. Facteurs associes a l'asthme sévère chez les patients asthmatiques suivis au Centre National Hospitalier de Pneumo-phtisiologie de Cotonou (Benin) en 2014. Pan African Medical Journal. 2015; 22:11
[143] Ahmed et al., 2017. Op cit page 3.
[144] Chowdhury A & Maulik SG. A Study of Correlation of Perceived Stress and Pulmonary Function Tests among Working Women in an Urban Population of West Bengal. International Journal of Research and Review. 2019 July; 6(7): 324-332.
[145] Siddharthan et al., 2019. Op cit page 11.
[146] Lehrer P, Feldman J, Giardino N, et al. Psychological Aspects of Asthma. Journal of Consulting and Clinical Psychology. 2002; 70, (3):P 691–711.

Table 2. SARA survey results of the African partner countries showing availability of tracer indicators for provision of services (WHO)[147]

Parameters / Country*/Year of survey**	Benin	Burkina Faso	Burundi	DR Congo	Guinea	Mauritania	Niger	Senegal	Uganda
Year of survey	**2015**	**2018**	**2017**	**2014**	**2018**	**2018**	**2015**	**2015**	**2012**
I. Trained staff and guidelines									
% Guideline available CRD diagnosis and management	27	10	5	20	35	12	28	30	78
% At least 1 trained staff CRD diagnosis & treatment	27	12	2	16	43	9	11	16	14
II. Equipment									
% Stethoscope	100	96	92	98	97	95	97	100	100
% Equipment for inhalers	13	2	5	12	5	7	7	9	4
% Peak flow meter	14	3	6	1	4	5	9	4	1
III. Medicines and commodities									
% Prednisolone (tablets)	12	3	41	58	18	6	6	2	44
% Epinephrine injectable	26	5	11	30	19	14	17	4	41
% Oxygen	34	3	8	12	13	12	8	5	36
% Salbutamol inhaler	56	43	22	25	22	16	29	20	28
% Hydrocortisone (tablets)	8	81	88	66	21	42	17	51	5
% Beclomethasone inhaler	13	2	2	6	15	7	3	2	3
Percent of facilities with all items	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**N/A**	**0**
Mean availability of tracer items %	**30**	**24**	**26**	**30**	**27**	**20**	**21**	**N/A**	**32**

Notes: *Information on Mozambique and Rwanda not available on the Internet. **More recent surveys possibly have been executed but they were not available on the Internet or they only covered part of the country or specific type of service.
***Please note that countries where more recent data were available showed degradation on the offer of these specific services.

[147] Burkina Faso, Ministère de la Santé (2018) Enquête nationale sur la disponibilité, la capacité opérationnelle et la qualité des soins dans les services de santé (SARA + QoC). Rapport Final. Ouagadougou, Burkina Faso.
Republic of Uganda, Ministry of Health (2013) Uganda Services Availability and Readiness Assessment 2012. Summary Report: Key findings in figures. Kampala, Uganda.
République de Guinée, Ministère de la Santé (2018) Enquête « Service Availability and Readiness Assessment, Data Quality Review and Quality of Care 2017 » (SARA-DQR-QoC 2017). Conakry, Guinée
République Démocratique du Congo, Ministère de la Santé Publique (2014) Indice de disponibilité et de capacité opérationnelle des services de santé (SARA RDC 2014). Kinshasa, DRC.
République du Bénin, Ministère de la Santé (2015) Disponibilité et capacité opérationnelle des services de santé. Enquête SARA. Cotonou, Benin.
République du Burundi, Ministère de la Santé et de la Lutte contre le SIDA (2017) Enquête d'évaluation de la disponibilité et de la capacité opérationnelle des services de santé (SARA). Rapport Final. Bujumbura, Burundi.
République du Niger, Ministère de la Santé Publique (2016) Rapport de l'évaluation de la disponibilité de la capacité opérationnelle des services de santé avec les outils SARA et Data Quality Review 2015. Niamey, Niger.
République du Sénégal, Agence Nationale de la Statistique et de la Démographie (ANSD) [Sénégal] et ICF International. 2015. Enquête Continue sur la Prestation des Services de Soins de Santé (ECPSS) 2015. ANSD et ICF International, Dakar, Sénégal.
République Islamique de la Mauritanie, Ministère de la Santé (2018) Indice de disponibilité et de capacité opérationnelle des services de santé (SARA). Nouakchott, Mauritanie.

c. Behavioural factors

i. Tobacco

While biomass fuels may account for a higher degree of CRD causation and worsening in LMICs including in the partner countries, the effects of tobacco should not be discounted. Cigarette smoking accounts for as much as 90% of COPD risks[148] in HICs, and estimates indicate that COPD eventually develops in 50% of all smokers.[149] Achieving a "*30% relative reduction in prevalence of current tobacco use in persons aged 15+ years*" is one of the nine voluntary global targets for 2025 to accelerate national efforts to address NCDs.[150]

Prevalence of tobacco smoking varies in SSA. According to the WHO Regional Office for Africa (WHO AFRO), in 2015, the tobacco use average prevalence amongst adults was 21% for males and 3% for females; youth prevalence was at 18% (21% boys; 13% girls); and half of adolescents (48%) are exposed to second-hand smoke.[151]

Table 3 provides tobacco consumption prevalence in partner countries.

Table 3. Tobacco consumption prevalence in partner countries, by sex.

Indicator	Crude Adjusted Prevalence %			Age-standardised Prevalence %		
Country	Both sexes	Male	Female	Both sexes	Male	Female
Benin	6.4	11.3	1.6	7.2	12.4	1.9
Burkina Faso	15.1	24.0	6.5	16.0	24.9	7.2
Burundi	11.5	17.2	6.0	12.6	18.8	6.4
DRC (Kinshasa)*	6.4	14.1	1.4	-	-	-
Guinea**	12.8	23.2	2.0	-	-	-
Mauritania***	18.9	34.2	5.7	-	-	-
Mozambique	13.3	22.4	4.9	14.4	23.4	5.4
Niger	8.5	16.2	0.8	8.6	16.3	0.8
Rwanda	11.5	17.7	6.1	13.3	19.7	6.9
Senegal	8.6	17.2	0.7	9.1	17.4	0.7
Uganda	7.3	12.3	2.5	9.8	15.5	4.0

Sources: Unless otherwise stated, all data are from 2018, published at WHO 2019[152]; * STEPS Survey 2005[153]; ** STEPS Survey 2009[154]; *** STEPS Survey 2006[155]. Prevalence from STEP surveys is crude prevalence.

[148] https://www.medscape.com/answers/297664-7343/what-is-the-role-of-cigarette-smoking-in-chronic-obstructive-pulmonary-disease-copd

[149] Laniado-Laborin R, Smoking and Chronic Obstructive Pulmonary Disease (COPD). Parallel Epidemics of the 21st Century. *Int. J. Environ. Res. Public Health* 2009, *6*, 209-224

[150] *The remaining voluntary global targets were*:25% relative reduction, overall mortality from cardiovascular diseases, cancer, diabetes, or chronic respiratory diseases; at least 10% relative reduction, harmful use of alcohol, as appropriate, within the national context; 30% relative reduction in mean population intake of salt/sodium; 10% relative reduction, prevalence of insufficient physical activity; 80% availability of affordable basic technologies and essential medicines required to treat major NCDs in both public and private facilities; 25% relative reduction in prevalence of raised blood pressure according to national circumstances; at least 50% of eligible people receive drug therapy and counselling to prevent heart attacks and strokes. https://www.who.int/nmh/ncd-tools/definition-targets/en/

[151] Yonga G. (2017) Implementing Tobacco Control Policies in Africa.. https://www.world-heart-federation.org/wp-content/uploads/2017/10/WHF-African-Summit-Day-1-Tobacco-Control-GYonga.pdf

[152] WHO (2019) Global report on trends in prevalence of tobacco use 2000-2025, third edition. WHO, Geneva, Switzerland. https://www.who.int/publications/i/item/who-global-report-on-trends-in-prevalence-of-tobacco-use-2000-2025-third-edition

[153] République Démocratique du Congo, Ministère de la Santé (2006). Enquête sur les facteurs de risque des maladies non transmissibles à Kinshasa, capitale de la RD du Congo selon l'approche STEPS de l'OMS. https://www.who.int/ncds/surveillance/steps/STEPS_DRC_Final.pdf

[154] République de Guinée, Ministère de la Santé et de l'Hygiène Publique et Organisation Mondiale de la Santé (2010) Note de synthèse de l'enquête STEPS. Conakry, Guinée https://www.who.int/ncds/surveillance/steps/2009_Guinea_FactSheet_EN.pdf

[155] République Islamique de Mauritanie, Ministère de la Santé et Organisation Mondiale de la Santé (2007) Enquête sur les Maladies non Transmissibles selon l'approche STEPwise de l'OMS : Enquête sur l'Hypertension Artérielle, le Diabète et autres Facteurs de Risque cardio-vasculaires à Nouakchott Mauritanie (janvier-juin 2006). Rapport d'enquête. Nouakchott, Mauritanie. https://www.who.int/ncds/surveillance/steps/STEPS_Report_Mauritania.pdf

Tobacco smoke contains substantial amounts of oxidants, some of which are in the gas form (e.g., carbon monoxide, hydrogen cyanide, and nitrogen oxides); some in the liquid vapour form (e.g., formaldehyde, acrolein, benzene, and certain N-nitrosamines); and others as particulate matter (nicotine, phenol, polyaromatic hydrocarbons, and certain tobacco-specific nitrosamines).[156] Varying amounts of these chemicals are inhaled by the active smoker; and would also be inhaled second- and third-hand. Second-hand smoke, otherwise referred to as passive smoking, is the inhalation of tobacco smoke emitted within the surroundings of a non-smoker. Third-hand smoke consists of residual tobacco smoke pollutants that remain on surfaces and in dust after tobacco has been smoked, and which are re-emitted back into the gas phase or react with oxidants and other compounds in the environment to yield secondary pollutants.[157] Chemicals in tobacco smoke damage the airways and lung tissues by triggering abnormal inflammation and repair, resulting to remodelling of the airway walls and destruction of small airways. [158]

Active smoking, and (passive) second-hand and third-hand exposure to tobacco smoke and its residuals are a cause of preventable suffering, disability and premature death primarily from asthma, COPD, cardiovascular diseases and cancer. Worse, second- and third-hand smoke affects a person throughout the life course, from the early foetal life, infancy, childhood and well into adulthood.[159, 160 161]

In the qualitative study conducted in Uganda by Van Gemert and colleagues[162], they noted that people, particularly in the tobacco-growing areas, deemed tobacco to be "safe" and would smoke both outdoors and indoors. Due to inculcation of their culture and easy access to tobacco products, most men, many of the elderly women and even young children smoked. They are also accustomed to have chronic cough and do not consider this as a health problem.

The damaging effects of tobacco consumption is well-established, and it is a recognised risk factor by partner countries' governments; they have implemented, to varying degrees, tobacco control policies in response to health and economic threats presented by increased tobacco consumption, particularly among the youth.

All partner countries have ratified the WHO Framework Convention on Tobacco Control (FCTC), the majority between 2005 and 2007, with Mozambique coming in much later in 2017. Despite having ratified the FCTC, implementation rates of the convention in these countries vary: laws take a long time to be approved and passed; and decrees fail to meet all FCTC requirements on smoke free environments as well as anti-smoking campaigns and regulation on advertising of tobacco products. Tables 4 (next page) and 5 (page 35) show the levels of implementation in partner countries and level of taxation for tobacco products.[163]

[156] https://cancercontrol.cancer.gov/sites/default/files/2020-06/m7_5.pdf
[157] Burton A. Does the smoke ever really clear? Environmental Health Perspectives. 2011 February; 119 (2): A71-A74.
[158] Laniado-Laborin, 2009. Op cit 23.
[159] Eisner MD & Forrestier F. Passive Smoking, Lung Function, and Public Health. American Journal of Respiratory and Critical Care Medicine 2006;173: 1184-1185.
[160] Bek K, Tomac¸ N, Delibas A, Tuna F, Tezic¸ HT, Sungur M. The effect of passive smoking on pulmonary function during childhood. Postgraduate Medicine Journal 1999; 75:339–34
[161] Masjedi MR, Kazemi H, Johnson DC, Effects of passive smoking on the pulmonary function of adults. Thorax 1990; 45: 27-31.
[162] Van Gemert et al., 2013. Op cit page 19.
[163] WHO (2003 updated 2004, 2005) WHO Framework Convention on Tobacco Control. Geneva, Switzerland. Available from: https://apps.who.int/iris/bitstream/handle/10665/42811/9241591013.pdf?sequence=1

Table 4. Regulations on Tobacco Control in Africa partner countries (2013-2015)

Country	Regulations
Benin	Law Concerning Regulation of the Production, Commercialization and Consumption of Cigarettes and Other Tobacco Products (2006); Decree Concerning Organisation of Control of the Production, Importation, Commercialization and Consumption of Cigarettes and Other Tobacco Products (2009); Inter-ministerial Order Specifying the ISO Standards Regarding the Production, Commercialization and Consumptions of Cigarettes and Other Tobacco Products (2011); Inter-ministerial Order Setting the Terms for the Use of Cigarettes and Other Tobacco Products by Smokers in Places for Shared Use (2011)
Burkina Faso	Decree Concerning the Regulation of Advertising and Places for Tobacco Consumption (1988); Law Public Health Code, Chapter VII (excerpts) (1994); Law Concerning the Code of Advertising 2001; Law Concerning Tobacco Control in Burkina Faso (2011); Decree Concerning the Packaging and Labelling of Tobacco Products (2011); Decree Concerning the Ban on Smoking in Public Places and Public Transportation (2011); Decree Establishing a National Committee for Tobacco Control (2011)
Burundi	Decree on Health Warnings and Prohibiting the Sale of Cigarettes to Minors and in Certain Public Places (2011)
Democratic Republic of the Congo	Ministerial Administrative Order on the prohibition of smoking in the outbuildings, facilities and offices of the Ministry of Health (2000); Ministerial Administrative Order setting the criteria to be applied to advertising for tobacco and alcoholic beverages (2002); Ministerial Administrative Order setting the criteria for assessing advertising for tobacco and alcoholic beverages as amended to date (2007); Administrative Order Bearing On Measures Applicable to the Use and Consumption of Tobacco, Tobacco Products and Derivatives (2007);
Guinea	N/A
Mauritania	Ministry of Health Social Affairs Circular on Smoke-free Ministry Facilities (2005)
Mozambique	N/A
Niger	Ministry of Trade, Transport & Tourism Order Regulating Tobacco Products Advertising (1992); Order on Warnings Labels on Tobacco Products (1996); Law on Tobacco Control (2006); Resolution and Deliberation on the Creation of the Parliamentarian Tobacco Control Network (2007); Decree Establishing the Modes of Enforcement Relative to Tobacco Control (2008); Ministry of Public Health Order Regulating the Content, Packaging Labelling of Tobacco Products (2012); Ministry of Public Health Ministry of Commerce Order Concerning the Opening Operation of Points of Sale of Tobacco (2012); Joint Administrative Order Concerning the Opening Operation of Points of Sale for Tobacco Products in Niger (2013); Joint Administrative Order Regulating the Composition, Packaging Labelling of Tobacco Products in Niger (2014)
Rwanda	Instructions of the Minister of Health Relating to the Protection of Non-Smokers Environment Against Damages and Bad Consequences of Tobacco (2005); Law Relating to the Control of Tobacco (2013)
Senegal	Ministry of Public Health Order Establishing a National Committee, Regional Committees, Departmental Committees on Tobacco Control (2009); Law Concerning the Manufacture, Packaging, Labelling, Sale Use of Tobacco (2014)
Uganda	The National Environment Regulations (Control of Smoking in Public Places) 2004

Source: Compliance to WHO Framework Convention on Tobacco Control (FCTC). Tobacco Tactics, University of Bath, UK https://tobaccotactics.org/wiki/fctc-compliance-in-africa/

Table 5. Tobacco Taxation and Affordability in Africa partner countries

Country	Taxation* %	Cigarettes less affordable since 2008**
Benin	4.9	No
Burkina Faso	41.6	No change
Burundi	42.8	No change
DR Congo	38.7	No change
Guinea	N/A	N/A
Mauritania	9.6	No
Mozambique	28.5	Yes
Niger	31.3	No change
Rwanda	55.9	No
Senegal	38.2	Yes
Uganda	39.9	Yes

***Taxation:** The share of total taxes in the retail price of the most widely sold brand of cigarettes.
****Affordability:** Per capita GDP needed to buy 2,000 cigarettes of the most sold brand increased on average between 2008 and 2018.
Source: WHO Framework Convention on Tobacco Control (FCTC) Secretariat; WHO 2019 Report on the Global Tobacco Epidemic (118-121)

Data from the WHO FCTC 2019, shows *Benin, DR of the Congo, Guinea, Niger, Senegal* and *Uganda* among the highest achieving countries enforcing bans on tobacco advertisement, promotion and sponsorship. *Benin, Burkina Faso* and *Uganda* are champions on smoke-free environments. *Senegal* and *Mauritania* have adopted tobacco control policies and developed National Tobacco Control Strategic Plans.

The *Centre for Tobacco Control in Africa* (CTCA), based in Uganda, provides technical and institutional support to governments in Africa with policy formulation, legislation and enforcement of tobacco control. [164]

> *The International Union Against Tobacco and Lung Diseases (The Union) "has supported the Ugandan Ministry of Health's tobacco control efforts since 2012, helping to develop a national strategic plan for tobacco control and stricter tobacco control regulations. In 2015, the Ugandan Parliament passed a ground-breaking law aligning the country with the world's strongest tobacco control policies and positioning it as a regional leader. The law secured some of the toughest restrictions on the distribution, sale and use of tobacco products in the region."*
>
> -https://theunion.org/our-work/africa/tobacco-control-in-africa

Little attention has been paid to tobacco cessation interventions in most of SSA.[165] Among partner countries, only *Benin, Guinea,* Senegal *and Uganda* have national tobacco cessation guidelines, with *Senegal* being the first low-income country to offer comprehensive cessation support, starting with a toll-free 'quit' line where counselling is provided on cessation and the various treatments available in the country are explained.[166,167]

[164] https://ctc-africa.org/
[165] Peer N, Naicker A, Khan M & Kengne AP. A narrative systematic review of tobacco cessation interventions in Sub-Saharan Africa. SAGE Open Medicine. 2020; 8: 1-12.
[166] Plan Stratégique National de Lutte Contre le Tabagisme 2013 – 2015 de Mauritanie. Available from: http://untobaccocontrol.org/impldb/wp-content/uploads/reports/mauritania_annex2_tobacco_control_strategic_plan_2013_2015.pdf
[167] WHO (2019) Report on the Global Tobacco Epidemic. WHO, Geneva, Switzerland. Available from: https://apps.who.int/iris/bitstream/handle/10665/42811/9241591013.pdf?sequence=1

iii. Food choices

Food choices are influenced by norms and tradition and the availability, accessibility and affordability of food. It is customary in SSA to have cereal- plantain- or tuber-based main dishes, which may or may not be supplemented with animal proteins, lentils, vegetables and fruits depending on availability. In certain cases, infants are only exclusively breastfed for the first three or four months and are then weaned with high-carbohydrate but low-nutrient cereal- or tuber-based soft food. The increasing availability of food secondary to globalisation has disrupted traditional food habits; however, while international trade has increased the availability of nutritious alternatives, it also increased the supply of highly processed and synthetic foods with additives at more affordable prices, particularly in urban areas. For instance, fries and soda which are high in trans-fats, sodium and sugars, have become a common meal in urban Africa.[168] Both traditional and non-traditional food have their associated nutritional deficiencies, which have been correlated with poorer respiratory function; and while part of the population may be aware of the importance of nutritional values, it should also be considered that a large number may not really have any choice but to subsist on what is available and what can be afforded.

d. Biological factors

i. Genetics

No publications on genome studies for asthma in the partner countries were found but there are several studies conducted elsewhere significantly associating African ancestry with asthma.[169, 170] Alpha-1-antitrypsin deficiency, initially thought to affect only Whites from Northern Europe and which increases the risk to develop CRDs, has been demonstrated among the indigenous populations of sub-Saharan Africa.[171] Its prevalence, however, is very low everywhere.

ii. Respiratory tract infections

There is strong evidence that respiratory viral infections secondary to the Human Respiratory Syncytial Virus (HRSV) and rhinovirus increase the risk of asthma from infancy to early adulthood.[172] The exact mechanism on how respiratory infections may lead to the development of asthma is currently unknown; this may be due to an interplay of immunologic reactions and structural damage in the lungs. There is a wide variation of the prevalence of HSRV infections in Africa, from as low as 0.6% to as high as 60.4%; among the partner countries, a high prevalence of HSRV in Benin (>30%) has been reported.[173]

Viral and bacterial respiratory infections trigger exacerbations of both asthma and COPD; infections cause inflammation of the airways and increased mucus production which would worsen airway obstruction.

iii. Coronavirus Disease of 2019 (COVID-19)

No articles regarding COVID-19 and CRD in the partner countries were available at the time the literature search was conducted.

Observational studies in Italy suggest that a one-unit increase in PM2.5 concentration (μg/m3) is associated with a 9% (CI95 6–12%) increase in COVID-19 related

[168] Oniang'o RK, Mutuku M, Malaba SJ. Contemporary African food habits and their nutritional and health implications. Asia Pacific Journal of Clinical Nutrition. 2003 February; 12(3): 331-336

[169] https://news.feinberg.northwestern.edu/2019/04/genetic-links-to-asthma-in-people-of-african-ancestry/ ;

[170] https://pubmed.ncbi.nlm.nih.gov/19290544/ ; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2647616/

[171] https://www.nature.com/articles/gim200532

[172] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5679206/

[173] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6185896/

mortality[174]. However, to what extent this association is a causal one needs further confirmation.

On a separate note, in studies also conducted elsewhere among those who contracted COVID-19, varying numbers from 10%[175] and up to >75%[176] have been reported to have persisting symptoms (now referred to as long COVID). Persistence of symptoms seem not related to severity of COVID-19 infection as this has also been observed among those with mild infection. The most common reported pulmonary symptoms are cough and shortness of breath.[177] Radiologic findings consistent with pulmonary dysfunction, for instance pulmonary fibrosis, have been noted.[178]

Chronic / persistent respiratory complications following COVID-19 may pose another burden as regards morbidity. While long COVID pulmonary symptoms may give rise to another high-burden CRD, it is also important to note that logically, symptoms of people with (poorly controlled) bronchial asthma and COPD would be potentiated by long COVID and add yet another layer to the suffering of people with CRD as regards costs and symptomatology.

iv. Pulmonary Tuberculosis (PTB)

PTB is a risk factor for chronic respiratory diseases. The lung injury caused by TB is diverse; there could be infiltrates, cavitation, bronchiectasis, fibrosis as stand-alone feature or in any combination. The majority of people with PTB manifest obstructive symptoms, which have been reported to persist in 18.4% to 86.8% post-treatment.[179] These lung abnormalities are consistent with damages that lead to or could worsen COPD and bronchial asthma.

Worldwide, Africa ranks second to South East Asia as to the number of TB cases, having 25% of the total global burden in 2020.[180] A population-based survey conducted in Uganda[181] demonstrated significant association between history of PTB and bronchial asthma. No scientific publications associating TB to COPD in the partner countries were found, but there are studies significantly linking TB to COPD elsewhere in Africa.[182, 183]

Van Gemert and colleagues' qualitative study in Uganda[184] indicated awareness of the population that TB is a serious disease. PTB treatment success rates range from 39% to 74% in Uganda; 61%-93% in Mozambique and 79%-93% in DRC.[185, 186]

---

[174] Eric S. Coker1 · Laura Cavalli2 · Enrico Fabrizi3 · Gianni Guastella2,4 ·Enrico Lippo2 · Maria Laura Parisi5 · Nicola Pontarollo5 · Massimiliano Rizzati2 · Alessandro Varacca6 · Sergio Vergalli2,5 The Effects of Air Pollution on COVID-19 Related Mortality in Northern Italy. Environmental and Resource Economics (2020) 76:611–634 https://doi.org/10.1007/s10640-020-00486-1

[175] https://www.bmj.com/content/370/bmj.m3026

[176] Huang, Huang, Wang, et al. 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *Lancet* 2021; 397: 220–32

[177] https://jamanetwork.com/journals/jama/fullarticle/2771111?appId=scweb

[178] Zhao Y, Shang Y, Song W, et al. Follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors three months after recovery. EclinicalMedicine; 2020: 25: 100463. Available from: https://www.thelancet.com/action/showPdf?pii=S2589-5370%2820%2930207-8

[179] Ravimohan S, Kornfeld H, Weissman D, et al. Tuberculosis and lung damage: from epidemiology to pathophysiology. Eur Respir Rev 2018; 27: 170077

[180] WHO Global Tuberculosis Report 2020. Available from: https://apps.who.int/iris/bitstream/handle/10665/336069/9789240013131-eng.pdf

[181] Kirenga BJ, de Jong C, Mugenyi L, Katagira W, Muhofa A, Kamya MR, Boezen HM, van der Molen T. Rates of asthma exacerbations and mortality and associated factors in Uganda: a 2-year prospective cohort study. Thorax. 2018 Oct;73(10):983-985

[182] Amaral A, Coton S, Kato B, et al. and the BOLD Collaborative Research Group. Tuberculosis associates with both airflow obstruction and low lung function: BOLD results. Eur Respir J 2015; 46: 1104–1112.

[183] Van Zyl Smit RN, Pai M, Yew WW, et al. Global lung health: the colliding epidemics of tuberculosis, tobacco smoking, HIV and COPD. Eur Respir J. 2010 January ; 35(1): 27–33.

[184] Van Gemert et al., 2013. Op cit page 19.

[185] Izudi J, Semakula D, Sennono R, et al. Treatment success rate among adult pulmonary tuberculosis patients in sub-Saharan Africa: a systematic review and meta-analysis. BMJ Open 2019;**9**:e029400.

[186] WHO, 2020. Op cit footnote 149.

v. Human Immuno-deficiency Virus (HIV) Infection

Infection with HIV and the use of antiretroviral therapy (ARTs) have been associated with COPD in both adults and children. Studies conducted in HICs (USA; Japan) as well as in SSA demonstrated higher prevalence of COPD in both adults and children with HIV, as compared with the general population.[187, 188, 189] A higher asthma prevalence of 15.5% among people living with HIV (PLHIV) as compared to 9.1% among those without HIV was noted in a general population survey in Uganda.[190] They also noted a significantly increased association of asthma with smoking, use of biomass fuels, and PTB among PLHIV.

The pathophysiology of the link between obstructive lung disease and HIV is not fully understood but is thought to involve chronic lung inflammation; increased sensitivity to inhaled irritants (particulate matter, noxious gases); obliterative bronchiolitis and bronchiectasis following pulmonary infections that PLHIV would be susceptible to (e.g., *Pneumocystis carinii*); worsening of pulmonary symptoms secondary to Immune Reconstitution Inflammatory Syndrome; and a low lung diffusing capacity. Increased viral load and/or uncontrolled viral replication and poor access to ARTs have likewise been associated with increased deterioration of lung function.[191]

Six years ago, an ambitious program to scale up treatment for HIV was formulated by the UNAIDS. Referred to as the 90-90-90, it was aimed that by 2020, [1] 90% of all people living with HIV will know their HIV status; [2] 90% of all people with diagnosed HIV infection will receive sustained antiretroviral therapy; and that [3] 90% of all people receiving ARVs will have viral suppression. From a global point of view, these targets were not reached last year: of the 38 million PLHIVs, 81% know they are HIV positive; 67% are on ARVs; and only 59% have viral suppression.[192] In the partner countries, *Rwanda* exceeded the targets for the first two goals (94% and 93%, respectively) and achieved 85% for the third goal; and *Uganda* achieved 84%, 87% and 88% respectively. Data was not complete or was not available for the rest of the partner countries, with achievements ranging from 62% (*DRC*) to 72% (*Niger*) for the first goal; 75% (*Niger*) to 88% (*Burkina Faso and Mauritania*) for the second goal; and 79% (*Benin*) to 83% (*Mauritania*) for the third goal.[193]

vi. Helminth infections

Helminth infections are pandemic in SSA, and their effects on asthma are quite paradoxical. Following the hygiene hypothesis, helminth infection may protect a person from developing allergic diseases including asthma.[194] However, certain helminth infections (e.g., Ascaris, Toxocara, Strongyloides) and treatment of helminth infections may cause or worsen asthma.[195]

[187] Githinji LN, Gray DM, Zar HJ. Lung function in HIV-infected children and adolescents. Pneumonia. 2018; 10: 6

[188] Nakamura H, Tateyama M, Tasato D, Haranaga S, Ishimine T, Higa F, Kaneshima H, Fujita J. The prevalence of airway obstruc- tion among Japanese HIV-positive male patients compared with general population; a case-control study of single center analysis. *J. Infect. Chemother.* 2014; **20**: 361–4.

[189] Hirani A, Cavallazzi R, Vasu T, Pachinburavan M, Kraft WK, Leiby B, Short W, Desimone J, Squires KE, Weibel S *et al.* Prevalence of obstructive lung disease in HIV population: a cross sectional study. *Respir. Med.* 2011; **105**: 1655–61.

[190] Kirenga BJ, Mugenyi L, de Jong C, Lucian Davis J, Katagira W, van der Molen T, Kamya MR, Boezen M. The impact of HIV on the prevalence of asthma in Uganda: a general population survey. Respir Res. 2018 Sep 21;19(1):184.

[191] Calligaro GL & Gray DM. Lung function abnormalities in HIV-infected adults and children. *Respirology*. 2015; 20: 24–32

[192] 90-90-90 Treatment for all. Available from: https://www.unaids.org/en/resources/909090

[193] Marsh K, Eaton J, Mahy M. Global, regional and country-level 90–90–90 estimates for 2018: assessing progress towards the 2020 target. AIDS 2019, 33 (Suppl 3):S213–S226

[194] Scott KM, Von Korff M, Ormel J et al., Mental Disorders among Adults with Asthma: Results from the World Mental Health Surveys. Gen Hosp Psychiatr. 2007; 29(2): 123-133.

[195]Amoah AS, Boakye DA, Yazdanbakhsh M, van Ree R. Influence of Parasitic Worm Infections on Allergy Diagnosis in Sub-Saharan Africa. Curr Allergy Asthma Rep. 2017; 17: 65

4. THE NATURAL EVOLUTION OF BRONCHIAL ASTHMA AS RELATED TO THE SOCIAL & STRUCTURAL DETERMINANTS IN THE PARTNER COUNTRIES

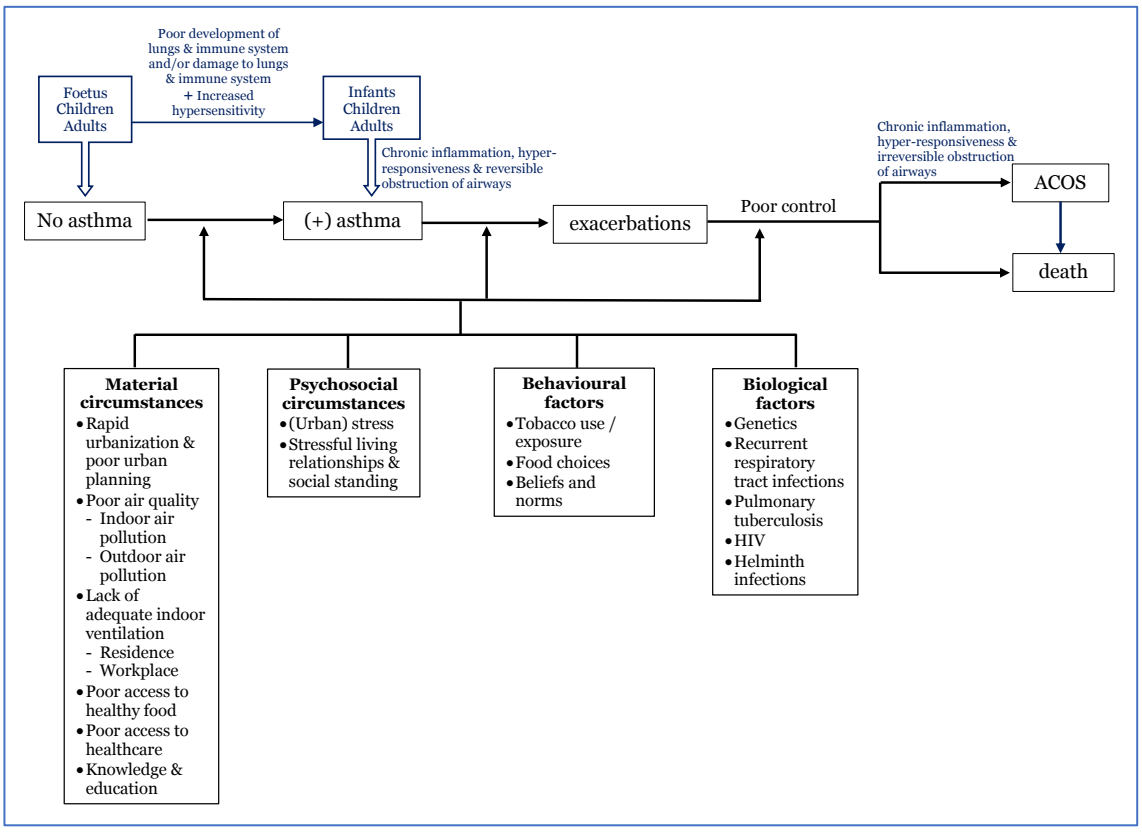
In SSA and the partner countries, the material and psychosocial circumstances and behavioural and biological factors mentioned in Figure 5 and discussed in Subsection V.3 have been linked to the development of asthma and triggering of exacerbations, and to its poor clinical management.

It has been observed that asthma is more prevalent in urban and peri-urban areas. Rapid urbanization, and the resultant upsurge of pollutions (air, water, ground, noise, etc) and stressful living conditions, compounded by poor urban planning with crowding in residences and intense road traffic; indoor and outdoor air pollution; poorly-ventilated dwellings and poorly regulated working conditions; decreased access to nutritious food; chronic stress; risky behaviour (especially as regards respiratory health); repeated respiratory tract infections; PTB; HIV; and history of helminth infections and treatment; and the inability of health systems to rapidly adapt and provide services to increasing numbers of people all contribute towards sub-optimal (respiratory) health and well-being.

The damage starts from the womb, when the mother is exposed to these SDHs, thereby leading to poor development of the lungs and a derangement in the immune system of the foetus causing this to over-react. The damage continues with continued exposure to these determinants among infants, children and adults, causing chronic inflammation of the lungs and hyper-responsiveness of the airways resulting in airway obstruction that could be reversed with prompt and proper treatment. However, continued exposure to pollution, allergens and irritants; poor nutrition; and suboptimal treatment will eventually lead to irreversible airway obstruction and/or asthma-COPD syndrome and/or premature death.

Figure 6 illustrates the natural history of asthma and the social and structural determinants that we identified in the partner countries.

Figure 6. The natural history of asthma and identified social and structural determinants in partner countries

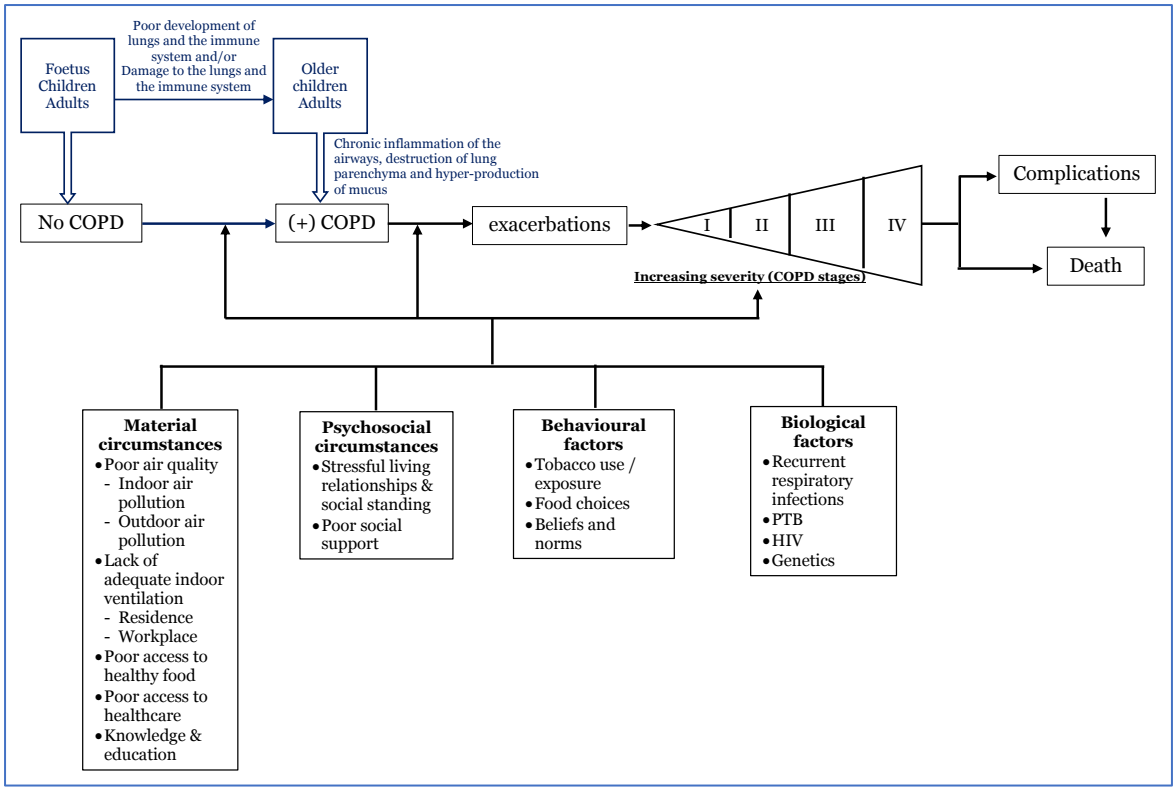


5. THE NATURAL EVOLUTION OF COPD AS RELATED TO ITS SOCIAL & STRUCTURAL DETERMINANTS IN THE PARTNER COUNTRIES

COPD prevalence has been noted to be higher in rural areas in SSA and the partner countries.

Figure 7 illustrates the natural history of COPD and the social and structural determinants that we identified in the partner countries.

Figure 7. The natural history of COPD and identified social and structural determinants in partner countries.



The more common causative agent is the use of biomass fuel in poorly ventilated dwellings. Cigarette smoke still plays an important role, particularly in tobacco-producing regions. An interplay of other factors that could affect both developing/immature and mature lungs such as scarring and fibrosis (e.g., secondary to HIV, PTB, repeated respiratory tract infections, pneumoconiosis/occupation-related lung disease) coupled with poor nutrition would lead to (further) obstruction of normal respiration.

Owing to the main cause, more women and people at a younger age have been documented to have COPD in SSA and in the partner countries. Exposure to biomass smoke is higher for women as they cook; these women may be pregnant thereby exposing the foetus as well. Younger children tend to stay close with their mothers, and girls as young as six years of age are already expected to have kitchen duties.

Exposure to biomass smoke from the womb/early childhood contributes to an earlier onset of COPD among this population. Early onset COPD is characterised as obstructive lung disease occurring at less than 50 years of age; [196] a 102% increase in COPD cases among people aged 30 years and more has been documented in the WHO AFRO Region from 1990 (14.1 million cases) to 2010 (28.5 million cases).[197] While this data may be relative to population growth, it also signifies that use of

[196] Soriano JB, Polverino F, Cosio BG. What is early COPD and why is it important? European Respiratory Journal. 2018; 52:1801448.

[197] Adeloye D, Chua S, Lee C, Basquill C, et al. and The Global Health Epidemiology Reference Group (GHERG). Global and regional estimates of COPD prevalence: Systematic review and meta-analysis. J Glob Health. 2015 Dec;5(2):020415

biomass fuel remains unaddressed. Continued exposure to risks and suboptimal treatment significantly contribute towards rapid deterioration – more destruction of lung parenchyma, increased exacerbations – even from a young age; subsequently, this will lead to complications such as heart failure, and premature death.

The more common causative agent is the use of biomass fuel in poorly ventilated dwellings.

6. COST

In the public health tradition, a health problem's cost is split up in *economic* cost and *social* cost. Economic cost, in turn, is divided in *direct* and *indirect* cost. Economic cost is measured using one metric only: monetary units.

Economic cost

Typically, total (economic) *societal cost* of a health problem is calculated as the sum of *direct costs* and *indirect costs*.

If *direct cost* is defined as the sum of expenditures to reduce or manage existing suffering caused by the health problem, there is no decent study of this in Sub-Saharan African contexts. Given that specific CRD services are mostly severely lacking in Enabel's partner countries, at present direct cost is certainly very low in terms of actual aggregate spending in these countries.

If *indirect cost* is defined as the sum of economic cost caused by loss of production due to incapacities linked to CRD, again there is no credible information about this for most African countries. This is not really surprising, as the theoretical difficulties inherent to such calculations in countries where large proportions of the population are in subsistence mode, with lots of under-employment (if considered from industrialised or post-industrialised economies' point of view) are rather formidable.

It might be added that even the published material on direct and indirect cost of CRD in economically more advanced countries is perplexing or confusing – to say the least – in terms of the range of results found. For example, one study (Foo et al. 2016)[198] reporting on total annual societal cost (direct + indirect) for COPD in 12 countries (ranging in economic performance from Mexico to USA), found a range from $3,012 (Italy), over $18,803 (UK) to $30,826 (USA) per patient per year. One constant within this diversity was the systematically higher values for indirect over direct cost (with one exception: France). Widely varying severity of disease in the populations included in the studies is a probable explanation for these disparities. Another study focusing on the evolution of total societal cost of COPD in South Korea from 2004 to 2013 (Kim et al. 2016)[199] concluded that total societal (economic) cost would be $310 per patient per year, this time with the lion's share being direct cost (59%). Clearly, there are important methodological issues in this kind of studies – which might be surprising, as the concepts are relatively clear.

Another approach is presented by an OECD Working Paper[200], tackling the cost of the health impact of *air pollution* (in Africa). This approach uses the concept of 'value of statistical life', i.e. a synthetic measure of the cost of premature mortality caused by air pollution, based on people's willingness to pay for a reduction of the annual risk of dying (from air pollution) from 3/100,000 to 2/100,000. The method calls for surveys to assess this willingness to pay, which have been performed in OECD member countries. Starting from the average result obtained in these surveys ($30 per person per year), adjustments are made for purchasing power parity income in LICs. Assuming an income elasticity of 1.0, the resulting 'value of statistical life' in DR Congo (a low-income country) would be about $150,000. Multiplied by the observed premature mortality due to air pollution in this

[198] Foo J, Landis SH, Maskell J, Oh Y-M, van der Molen T, Han MK, et al. (2016) Continuing to Confront COPD International Patient Survey: Economic Impact of COPD in 12 Countries. PLoS ONE 11(4): e0152618. doi:10.1371/journal.

[199] Jinhyun Kim, Tae Jin Lee, Sungjae Kim & Eunhee Lee (2016) The economic burden of chronic obstructive pulmonary disease from 2004 to 2013, Journal of Medical Economics, 19:2, 113-120, DOI: 10.3111/13696998.2015.1100114

[200] Rana Roy (2016) The Cost of Air Pollution in Africa. Working Paper 333. OECD Development Centre

country, this would yield a total cost of ***$10.2 billion*** per year. Applied to a country like Mauritania, the 'value of statistical life' would be $530,000; multiplied by the annual premature mortality due to air pollution observed in Mauritania (a lower-middle-income country with a much smaller population of about 4.5 million) this would yield a total cost of ***$159 million*** per year.

Although this methodology may appear rather artificial to some, economic theory would consider these figures to be the *cost*-component in formal *cost-benefit analysis*. In other words, (effective) interventions, capable of reducing air pollution-linked premature mortality to a specified result, produce a net economic benefit if they cost less than this cost-component. In economically advanced countries where air pollution levels have been significantly reduced over the last decennia, this C/B calculation has yielded highly profitable results.

It is to be kept in mind, of course, that premature mortality due to *air pollution* is not to be reduced to CRD alone. The majority of these deaths is linked to cardio-vascular disease and acute pulmonary illness – CRD remaining an important but lesser contributor.

On the other hand, and independently of the cost calculations, the burden of *premature mortality* due to air pollution in Africa is by now of the same order of magnitude as other major risk factors like unsafe water, unsafe sanitation and childhood undernutrition. And in *Sub-Saharan Africa as a whole*, indoor air pollution is – so far – the major component of this mortality hazard.

Social cost

Conceptually, social cost is defined as the negative impact on proper functioning and potential well-being of the group (from household to society) to which people suffering from the condition belong, caused by their health problem.

This social cost is not necessarily easily measurable because there is no universally applicable metric – unlike economic cost, which is always measured in monetary units. However, it can be very important, as exemplified by the dramatic consequences of the high young adult AIDS mortality in Southern Africa around the turn of the century: high numbers of orphans, lack of health personnel and teachers, judiciary systems breaking down, etc.

In the case of CRD, social cost is less spectacular, but far from negligeable. Prolonged absenteeism from school leads to educational deficits; sick children divert parents' attention from other duties (and from other children); absenteeism from work creates collateral problems (on top of the loss of income and indirect economic cost); 'presenteeism' (presence at the workplace without being able to contribute much to production because of sickness-induced incapacity) creates similar collateral problems.

Effective CRD care provision can significantly reduce these social costs.

7. POTENTIAL ACTORS

The main actors in partner countries are *national governments* through policy-making, promulgation and enforcement of laws, and provision of services since in Enabel partner countries the public sector is the major health services provider. Other ministries than health are essential to tackle CRD: environment, justice, trade and industry, finance, agriculture amongst others, as was done in the Rwanda HSDP multisector strategy for NCD.

Very important actors are *technical and financial partners* (TFP), including UN entities, whose support to NHPs and HSDPs implementation are crucial. Almost all major NGOs and multi- and bilateral co-operations intervene in partner countries, at different levels, sectors and programmes, involving the environment and/or related areas and some of them are directly involved in the health sector. All TFP are concerned with NCD, but to our knowledge at the moment of this review, none has a specific action on CRD in partner countries.

Private for-profit services provision is present and significant. However, among partner countries, comprehensive knowledge of their actual service provision is lacking except in countries where USAID's SHOPS projects, with support from the World Bank, carried out thorough assessments (*Benin, DR of the Congo, Senegal*) or macro level assessments (*Burkina Faso, Mauritania, Niger*).[201,202] Nonetheless, in some countries it is possible to determine the percentage of private services that provide care for CRD through the analysis of their SARA Surveys (Table 2, page 31).

Civil and professional associations/organisations have been quite active in developing awareness and advocacy towards NCD but less so to CRD, with the exception of tobacco control. Almost all partner countries have civil society involved in tobacco control campaigns/interventions. The NCD Alliance merits attention.[203] Initiated in 2009 by the International Diabetes Federation (IDF), the Union for International Cancer Control (UICC), the World Heart Federation (WHF), and joined later by the International Union against Tuberculosis and Lung Disease (The Union), the NCD Alliance has been pivotal in catalysing political action around NCDs. Today it is a strong global network of more than 2,000 organisations in 170 countries, from which 6 of the partner countries are members (*Benin, Burundi, Niger, Mozambique, Rwanda* and *Uganda*) and have created their own national NCD alliances.[204]

Appendix III provides an overview of the alliances / associations / coalitions / networks / NGOs / initiatives working on NCD, CRD in particular, and/or risk factors identified in this scoping review and through the questionnaires sent to partner countries.

Involvement of the media as a useful tool for disseminating and forwarding actions by the different stakeholders and actors should be strongly considered.

THE "ACTIONABLE" COMPONENTS

Although bronchial asthma and COPD may have different characteristics, there are more than enough commonalities especially regarding factors that may precipitate and worsen the conditions, which could be points for action that may address primary and secondary prevention of either.

The complexity of the social and structural determinants of these CRDs and how they are intertwined with one another point out that it might not be possible to have only one specific action on a particular SDH that will be carried out by only one sector; nevertheless, actions will also most probably bring about collateral positive effects. The complexities are illustrated in Figure 8 (next page).

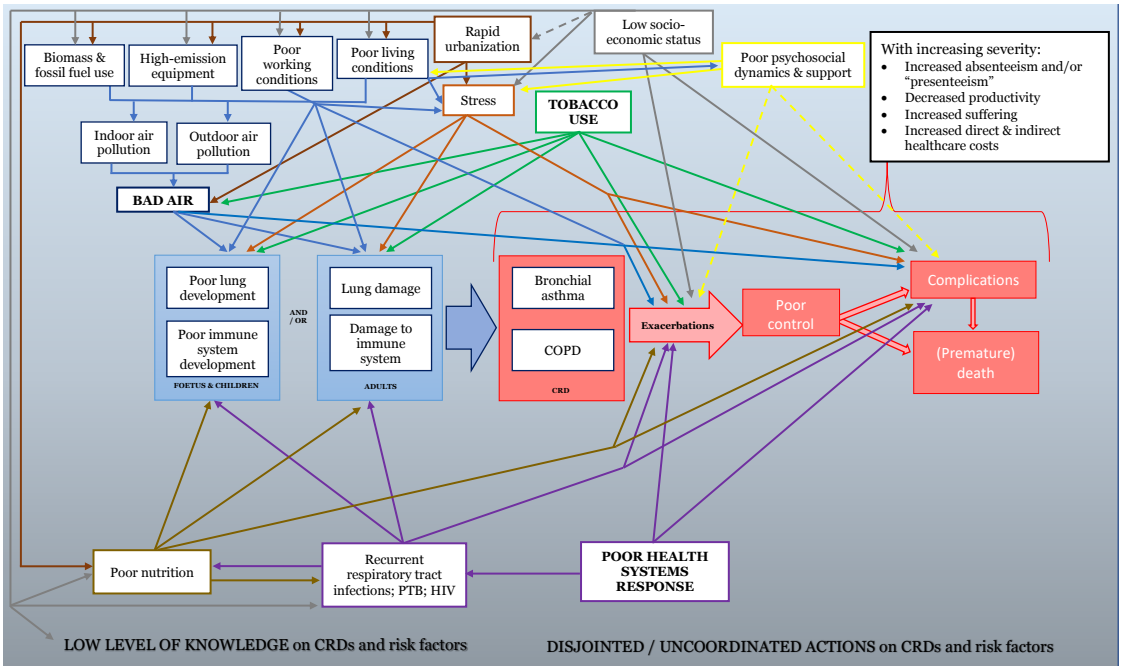
[201] *Sustaining Health Outcomes through the Private Sector* (SHOPS) Plus is USAID's flagship initiative in private sector health. The project seeks to harness the full potential of the private sector and catalyse public-private engagement to improve health outcomes in family planning, HIV/AIDS, maternal and child health, and other health areas. https://www.shopsplusproject.org/

[202] SHOPS Plus. 2019. *Democratic Republic of the Congo* Private Health Sector Assessment. Brief. Rockville, MD: SHOPS Project, Abt Associates Inc. https://www.shopsplusproject.org/resource-center/democratic-republic-congo-private-health-sector-assessment ; Brunner, B., Carmona A., Kouakou A. et al. (2014) The Private Health Sector in *West Africa*: Six Macro-Level Assessments. Bethesda, MD: SHOPS Project, Abt Associates Inc. *(From partner countries: Burkina Faso, Mauritania and Niger)* https://www.shopsplusproject.org/sites/default/files/resources/West%20Africa%20PSA%20report%20-%2011_7_14%20FINAL.pdf ; SHOPS Project (2013) *Benin* Private Health Sector Assessment. Brief. Bethesda, MD: SHIPS Project, Abt Associates Inc. https://www.shopsplusproject.org/sites/default/files/resources/Benin%20Private%20Health%20Sector%20Assessment%20Brief.pdf Brunner, B., Barnes J., Carmona A. et al (2016) *Senegal* Private Health Sector Assessment: Selected Health Products and Services. Bethesda, MD: SHOPS Project, Abt Associates Inc. https://www.shopsplusproject.org/sites/default/files/resources/Senegal%20Private%20Health%20Sector%20Assessment_Selected%20Products%20and%20Services.pdf

[203] https://ncdalliance.org/

[204] Alliance MNT *Bénin* https://ncdalliance.org/alliance-mnt-b%C3%A9nin; Burundi NCD Alliance https://ncdalliance.org/burundi-ncd-alliance-bncda ; Aliança *Moçambicana* de luta contra doenças não transmissíveis (no web site); Coalition *Nigérienne* contre les MNT https://nigerinter.com/2019/10/sante-inoussa-saouna-se-prononce-sur-la-mise-en-place-de-la-coalition-de-lutte-contre-les-maladies-non-transmissibles/ ; *Rwanda* NCD Alliance http://www.rwandancda.org/about.html ; *Uganda* NCD Alliance https://uncdaug.org/ ; and the *East Africa* NCD Alliance https://ncdalliance.org/east-africa-ncd-alliance-initiative.

Figure 8. The social and structural determinants of CRD and identified actionable components



The SDH and issues for which strategic actions could be applied are:

(1) Poor air quality;
(2) Tobacco use;
(3) Poor health systems response to the issues of bronchial asthma and COPD;
(4) Misperceptions and poor information on CRD and its determinants at the community and patient levels; and
(5) Disjointed/Uncoordinated/Individualised responses to CRD and its determinants.

Air quality plays a significant role in the causation and worsening of bronchial asthma and COPD. In Africa, both indoor and outdoor pollution are significant concerns that could be modified with appropriate action to control emission of noxious and harmful substances. The level of tobacco regulation is still in its infancy in most of the partner countries and implementation of tobacco control and the FCTC could be augmented. Attention can be brought forward towards prioritization of occupational health and safety; from legislation to implementation and monitoring. With few exceptions, health systems response to CRDs is generally poor to non-existent in the partner countries. Appropriate support and capacity strengthening could be directed towards provision of good quality care that could improve service delivery not only for CRDs but also to address identified risks and promote health and well-being. Engagement of patients and communities towards recognition of and propagating actions to address CRDs and associated SDH; for instance, asthma and COPD patient groups could act as a pressure group for a more healthy environment and better care; women's associations can motivate their members to cook differently; religious organisations can call upon their 'flock' to show more respect for 'mother earth' and pollute it less; media could sensitize the general population about the dangers of pollution; community associations could help to clean the environment; trade unions can push for prioritisation of occupational health and safety including personal protective equipment for workers; farmers associations and cooperatives could introduce agricultural practices that use less pesticides; the wider community could work towards formulating appropriate actions on micro-insurance institutions/mutual health organisations that have 'business interest' in having less clients with health problems; etc. Various groups can be stimulated to cooperate towards harmonious and synergistic actions, including a multisectoral approach to NCDs as is being done in Rwanda.

Acting against these challenges would help achieve the following sustainable development goals (SDG) in the partner countries:

- SDG 3 - Strengthening of health systems and services to help ensure healthy lives and promote well-being for all at all ages;
- SDG 5 – gender equality; bringing forth appropriate and adequate attention to women and children;
- SDG 7 – affordable and clean energy;
- SDG 8 – decent work;
- SDG 11 – resilient and sustainable cities;
- SDG 12 – sustainable consumption and production / renewable energy;
- SDG 13 – combat climate change; and
- SDG 15 – sustainably manage forests.

CHAPTER VI

"HOW DO WE GET TO WHERE WE WANT TO BE?": PROPOSED STRATEGIC ACTIONS

A. "Clean" Air: energy efficiency improvements and making available "cleaner fuel"

In tackling bad air, the general principle should be to start from felt needs and/or discomforts. This could mean:

- At household/community level
  - Understanding felt needs or discomforts concerning indoor and outdoor pollution;
  - Establishing the link with sickness(es);
  - Assessing available alternatives and obstacles in the areas of accessibility and affordability of clean and efficient energy sources, prioritizing solutions that signify improvement in quality of life rather than 'sacrifice', examining in terms of
    - Time saving
    - Noxious smoke avoiding
    - Bad smell avoiding
    - Money saving
    - …
  - Identifying and examining wider policy interventions needed for better accessibility and affordability of clean(er) energy at household/community level
- At local health system level:
  - Starting from felt needs, specifically asthma and COPD (chronic cough)
  - Assessing feasible protocols for treatment and secondary prevention
  - Making the link with environmental conditions (indoor and outdoor)
  - Setting the example in the whole operational HS infrastructure
- At central policy level:
  - Communicating clearly – sharing the narrative about the necessity to ensure acceptable air quality
  - Encouraging efficiency of fuel use; possibilities include
    - Vulgarizing efficient cooking techniques
    - Fiscal measures encouraging clean fuels
    - Promoting public transport and looking into alternative modes of transportation (or converting current modes of transportation) that use less fossil fuel or are powered by clean energy / discouraging overdevelopment of individualized singular/one-person transport
    - …
  - De-subsidizing fossil fuels
  - Subsidizing clean energy sources
  - Giving due attention to air quality in urban planning
  - Formulating, implementing, enforcing workplace environmental regulations and tobacco control policies (regulate advertising, fiscal measures… starting with discouraging youth from taking up cigarette smoking)
- At the level of civil society / NGOs / (inter)national advocacy organisations:
  - Promoting clean air as a "public good"
  - Participating in the debate leading to a mobilizing narrative on clean air
  - Each in their chosen domains to
    - Optimise access/affordability of appropriate CRD care
    - Optimise implementation of programs aiming at primary prevention (air quality)
    - Seek complementarity and possibly synergy to reach shared goals

Ahuja and Tatsutani[205] indicate that *energy efficiency improvements* offer the largest and least costly emissions-reduction potential. Improving energy efficiency also offers important ancillary benefits such as savings in energy cost, reductions in emissions of conventional pollutants, a reduction in the dependence on imported fuels and improved economic competitiveness.

Energy efficiency improvements can be applied to decrease road traffic emissions and/or address indoor domestic pollution in the partner countries; this would entail improving vehicle performance, improving efficiency and emission control and introducing sustainable low-carbon biofuels for the former, and improving current cookstoves and introducing sustainable, cleaner alternative (biomass) cooking fuel (e.g., pellets, briquettes) for the latter (noting that the better alternative would be the "clean" cooking fuels such as liquid petroleum gas). At the same time, the subsidies for conventional fossil fuels could be reduced gradually and be realigned to provide new subsidies for more sustainable forms of energy or more efficient technologies.

Ways to support and work with ECOWAS and EAC to strengthen implementation of the *African regional fuel economy roadmap* could be explored in each of the partner countries.

The partner countries can be encouraged to join IRENA, the Clean Cooking Alliance and/or other organizations and agencies working on clean fuel and energy efficient technologies. They should also be motivated to devise mechanisms to increase accessibility and affordability of clean cookstoves and cleaner fuel. To note, considerable funding to deliver clean cooking solutions in Africa is available.[206]

B. Tobacco Control and smoking-cessation / prevention of initiation support

Implementation of the FCTC in the partner countries can be intensified. At the same time, more support could be allocated for smoking cessation activities. Skills training and education for smoking cessation and prevention of smoking initiation counselling is expected to be included in the basic CRD package training of healthcare workers. A major priority would be to discourage youth from taking up the habit of cigarette smoking (as it is much easier not to start smoking than to quit).

Tobacco control and FCTC implementation is easier said than done; the tobacco industry is very aggressive in LMICs and tends to interfere in country policy making. Strong political will and local and international support are needed in drafting and implementing (national) strategic plans for tobacco control and stricter tobacco control regulations such as tough restrictions on the distribution, sale and use of tobacco products. There are numerous organizations that can be tapped for support, a list of which is available from the WHO website (www.who.int › tobacco › atlas29) and in Appendix III.

A possible "win-win" solution is to raise excise taxes on tobacco, especially among the partner African countries which have not yet done so or in which affordability of tobacco has not markedly been changed. Simulation shows that with an average annual cigarette price increase of 9.51% (primarily to higher tobacco tax), the average annual cigarette consumption would decrease by 3.56%, and the average annual tobacco tax revenue would increase by 16.20%.[207] Revenues could then be used to finance various CRD activities: from health systems actions (training of healthcare workers, making CRD medications available), to subsidies towards achieving cleaner air (e.g., biofuel, clean cookstoves, etc.)

[205] Ahuja D & Tatsutani M. Sustainable energy for developing countries. Sapiens. 2009;2(1). Available from: https://journals.openedition.org/sapiens/823#tocto1n5

[206] See: https://www.cleancookingalliance.org/news/11-30-2020--afdb-european-commission-to-invest-millions-in-spark-africa-fund-to-support-clean-cooking.html

[207] Ho , LM., Schafferer, C., Lee, JM. *et al.* Raising cigarette excise tax to reduce consumption in low-and middle-income countries of the Asia-Pacific region:a simulation of the anticipated health and taxation revenues impacts. *BMC Public Health* 2018;18:1187.

C. Health Systems Strengthening: closing the gap for CRD care services

First line health services should be equipped to offer a *basic CRD care package* that includes (1) primary, secondary and tertiary prevention of bronchial asthma and COPD. This should not be interpreted as creation of another vertical program, but rather integrating the care for bronchial asthma and COPD with other health services. This would mean: training and support to existing healthcare workers to develop the needed skills and obtain the necessary knowledge to diagnose and treat bronchial asthma and COPD and provide health promotion and prevention activities regarding modifiable risk factors including smoking cessation; and (2) sustained availability of diagnostics and therapies for asthma and COPD.

To prevent overburdening specific healthcare workers, specific CRD care package tasks can be distributed among the different cadres of healthcare workers; assigning standardizable tasks for which algorithms could be prepared to healthcare staff with lower levels of expertise, and tasks requiring complex clinical decision-making to staff with higher levels of expertise.[208]

Referral mechanisms for higher level of care for CRDs should likewise be strengthened, including making available pulmonary rehabilitation services to augment disability limitation.

The Global Initiative for Asthma (https://ginasthma.org) and the Global Initiative for COPD (https://goldcopd.org) have readily available resources to guide diagnosis and treatment, and the guides are available in English and French. Use of these resources could be optimised.

While *equipment* for full pulmonary function testing (e.g., spirometers, arterial blood gas analysers) can be made available in second- or third- level hospitals, these would not be expected in health centres. Nevertheless, first line health facilities should be equipped with peak flow meters (retail prices ranging from €10,00 for a plastic with spring system to €120,00 for a digital/electronic one) and, possibly, pulse oxymetres (with retail prices ranging from €10,00 to €60,00). Naturally, skills of healthcare workers in using the equipment and in interpreting results will need to be developed (as part of the CRD basic care package training).

Appropriate *reliever and controller medications* should be included in the national essential medicines lists (NEML) of the partner countries, based on the stepwise treatment of bronchial asthma and COPD. The following could be made available: inhaled short-acting beta-agonists, inhaled or oral corticosteroids, inhaled anticholinergics for symptom relief; and combination inhaled corticosteroid + long-acting beta-agonist, inhaled corticosteroids, leukotriene modifiers, for symptom control.[209] Naturally, improving access to medications should also address affordability.

Access to oxygen should also be facilitated (noting that this has already proven to be an important bottleneck in the COVID-19 crisis).

D. Community & Patient Engagement: involving communities and patients to act towards addressing determinants of CRDs, controlling risk factors and bringing about good control of bronchial asthma & COPD

While the health system plays a major role in health promotion and prevention activities to control risks for CRDs, other sectors play vital roles in providing environments to stimulate people to do the things needed to be done to protect themselves against development and worsening of bronchial asthma and COPD.

The reviewed publications point to a low level of awareness of CRD and risk factors among people with the condition themselves and in the general population. However, it would not be ideal to think

[208] Ku & Kegels successfully implemented a service delivery model for diabetes (or other chronic conditions) involving task delegation in an earlier work in the Philippines. For the model, see: Ku GM & Kegels G. Adapting chronic care models for diabetes care delivery in low-and-middle-income countries: A review. *World J Diabetes* 2015 May 15; 6(4): 566-575. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4434077/pdf/WJD-6-566.pdf

[209] Global Initiative for Asthma. op cit page 9 & Global Initiative for Chronic Lung Diseases op cit page 10.

of engagement activities as a one-size-fits-all solution; rather, it should be tailored depending on the degree of awareness of the person and of the different sectors in the community.

1. PATIENT ENGAGEMENT[210]

   The WHO defines "patient engagement" as the *process of building the capacity of patients, families, carers, as well as health care providers, to facilitate and support the active involvement of patients in their own care, in order to enhance safety, quality and people-centredness of health care service delivery*.[211]

   Involvement of the patient in caring for him/herself entails more than promoting simple compliance to prescribed medications and mere adherence to the therapeutic regimen.[212] A collaborative approach[213] that takes into consideration not only the biomedical aspects of the disease or the condition but also the psychosocial aspects of the patient as a person may elicit better participation of the person to be engaged for better (self-)care and to be involved in health service delivery. Making patients/clients co-producers of their health can improve clinical outcomes and reduce health delivery costs.

   Barello and Graffigna[214] introduced a stepwise process for patient engagement (Figure 9, succeeding page), wherein a patient is recognised to undergo different phases based on their level of awareness and ability to do the things needed to be done to care for their condition and themselves: blackout, arousal, adhesion and eudaimonic project. In the "blackout" phase, a person newly diagnosed to have a chronic condition falls into an initial state of emotional, behavioural and cognitive blackout determined by this critical event that appears unexpected and out of their control. It is deemed that this person would be in a "pre-contemplative" state and may be fully dependent on a paternalistic model of medical care. People in this stage can be provided education about the condition, raising their awareness that they can participate in the care for their condition. In the subsequent phase of "arousal", the person then becomes hyper-attentive for all symptoms his/her body produces. In the early contemplative stages, perceptions of self-efficacy[215] in caring for the self may already be felt. Self-management education and support can thus be provided for the person to have the resources to know what needs to be done when, and to have the necessary information for (clinical) decision-making; behaviour-change would also be enforced at this time. Self-care may be fully realized in the next phase as the person adopts engagement. The "adhesion" phase comes when persons have enough knowledge and behavioural skills to effectively adhere to medical "prescriptions" and feel sufficiently confident in their own emotional strength to cope with their health condition. At this point, the patient may already be empowered enough to veer away from the paternalistic model of medical care and move towards a collaborative model. SME/S would ideally still be needed, for the person to "learn" to incorporate activities of "medical self-care" to their lives and to be fully equipped to make decisions and compromises in doing so. Finally, the state of "eudaimonia", where people with NCDs can have the opportunity to veer away from the "patient" label and consider their condition and things needed to be done for it as one of the many facets of their daily lives.

[210] This subsection is inspired by a previous work of Ku (2015) Institutionalization of Patient Engagement and Consultation within the Structures and Systems of the Department of Health**.** Available from: https://www.who.int/medicines/areas/coordination/KuDalmacionBajaPatientEngagement.pdf?ua=1

[211] WHO. Patient Engagement: Technical Series on Safer Primary Care. Geneva: World Health Organization; 2016. Available from: https://apps.who.int/iris/bitstream/handle/10665/252269/9789241511629-eng.pdf

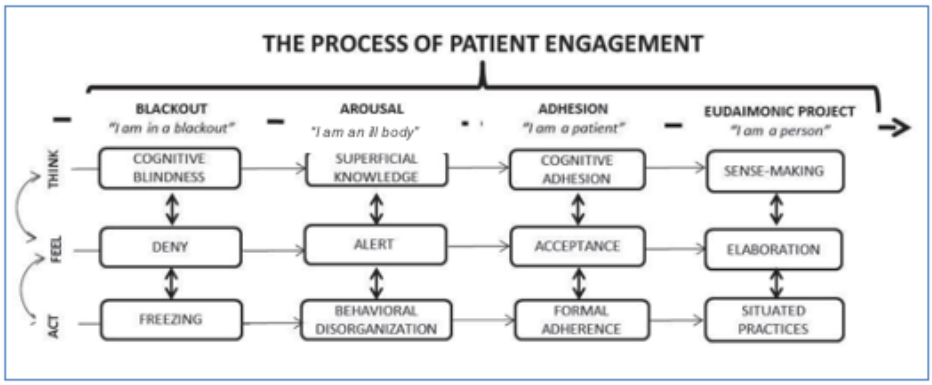
[212] Delamater AM 2006. Improving patient adherence. *Clinical Diabetes* 24:71-7.

[213] Wagner, EH. Chronic disease management: what will it take to improve care for chronic illness? *Eff Clin Pract* 1998;1(1): 2-4.

[214] Barello S, Graffigna G 2015. Patient engagement in healthcare: pathways for effective medical decision-making. *Neuropsychological Trends* 17. Available from: http://www.ledonline.it/NeuropsychologicalTrends/allegati/NeuropsychologicalTrends_17_Barello.pdf

[215] Bandura A. Self-efficacy: toward a unifying theory of behavior change. Psychol Rev 1977;84:191-295.

Figure 9. The patient engagement model.



Different levels of preparations would be needed to put patient engagement into action:
(1) Central level / "top" preparations for initiation of engagement;
(2) Training and education of "engagers" and local trainers/supervisors (as part of the "basic CRD package" training and education);
(3) Provision of education and support to CRD patients; and
(4) Grooming and further training and support of expert CRD patients as "engagers".

Preparatory activities are needed to build and strengthen capacities to provide education and support towards engagement of patients. This would include (a) elaboration of policies and related *implementation rules and regulations* to support patient engagement as needed; (b) recruitment of people with the necessary expertise; (c) development of a curriculum for training and education of "engagers" and (local) trainers; (d) production of materials for the training and education of engagers; (e) the design and production of materials for actual patient engagement (e.g., education and support, health promotion and behaviour change materials, etc.). The next set of activities would be the provision of training and education to the "engagers", and training of trainers and supervisors at the local level. Training and education on patient engagement will be assimilated to the "basic CRD package" training, previously described in Subsection VI.6. Once education has been provided and skills developed, the provision of education and/or support to people with CRDs, tailored according to their level of awareness and self-efficacy can commence. As more patients progress towards full engagement, they will reach a phase where they themselves could already be equipped with the ability to engage other patients themselves, akin to the peer educators for HIV or diabetes.[216]

2. Community engagement

Akin to patient engagement, community engagement promotes active involvement of community members in actions and activities that improve the health and well-being of and reduce risks to community members.

Engagement of communities would involve engaging community "authorities" (local government, specific groups, civil society) at one hand and the general population at the other, for them to be made aware of and stimulated to act on and participate in activities regarding CRDs and risk factors.

Actions on the part of those who have the authority would include support and implementation of national laws and enactment of local policies and laws to regulate identified risks (e.g., vehicle emissions, tobacco, waste management, etc), provision of support and a conducive environment to encourage behaviour change, and making available the necessary services for the control and case management of bronchial asthma and COPD and their risks.

The general population needs to be stimulated to become aware of bronchial asthma and COPD and related risks, to demand for support and a conducive environment to change their behaviour, and be convinced of the importance of adoption and adherence to behaviour that would eliminate much

[216] https://www.unicef.org/infobycountry/files/PeerEducationUNAIDS.pdf

of the modifiable risks. A possible catalyst to initiate these actions can be the health promotion activities that will be implemented with the basic CRD package.

However, it should be kept in mind that community actions will require a multi-sectoral approach and not only by the health system, as actions and activities can range from increasing adherence to healthy lifestyle and smoking cessation (which can be initiated by the health sector through health promotion/prevention activities) to adoption of clean cookstoves and use of clean fuel (which would need multi-sectoral efforts).

E. Synergy and complementarity

The European Commission[217] defines *synergy* as joint or coordinated efforts to achieve greater impact and efficiency. Synergy and complementarity are a top priority of the Belgian Development Cooperation and can improve the impact of development cooperation interventions. Logically, collaboration between two or more agencies acting on the same challenges would negate duplication of work and has the potential to fill-in individual gaps, maximize use of resources, and could facilitate more efficient and faster implementation of solutions and with greater coverage.

Synergy should not only occur among agencies working on similar solutions; rather, synergy should be encouraged among agencies working on varied solutions to address interconnected challenges. In the case of CRDs, solutions are diverse and includes actions for specific identified determinants (e.g., climate change actions; provision of sustainable and clean energy sources/electricity/clean fuel; waste management measures; tobacco control); these may be broad (for instance, actions towards achieving cleaner air) or quite precise (for example, more pedestrian-friendly transport policies). Identifying and putting together different sectors in a single collaborative group may prove to be challenging; however, "sub-groups" could be formed for synergistic and complementary actions.

[217] Available from: https://ec.europa.eu/regional_policy/sources/docgener/guides/synergy/synergies_en.pdf

CHAPTER VII

WHERE DO WE BEGIN? STRATEGIES FOR (MORE SUCCESSFUL) IMPLEMENTATION OF STRATEGIC ACTIONS

A. CONSIDERATIONS FOR STRATEGY CONTEXTUALISATIONS & IMPLEMENTATION

"*Strategy*" may have a different meaning for Enabel as compared to partner country authorities or organisations. For Enabel, modes of action fall into several categories that includes projects, programs, transversal issues, and (inter)national alliance building/strengthening.

Enabel's initiatives should (at least mainly) be in harmony with partner countries' stated priorities. When there is convergence between Enabel's and countries' priorities, a common strategy formulation can be reached, with a division of tasks and inputs to be decided through negotiation.

Enabel is rather unique among international cooperation agencies through its practice of project 'co-management', where management of project/program implementation is shared by the partner country's and Enabel's representatives, enhancing mutual commitment and feedback into national policy levels.

When considering CRDs as *medical conditions to be treated* (secondary prevention and treatment), the response may be considered more or less straightforward. Various elements or tiers of the Health System can be strengthened and equipped to deal with the conditions (asthma/COPD) in the most feasible and appropriate way.

When the objective is to tackle *causes and determinants* (shifting to primary prevention of CRDs), things become (more) complex. A common element of these causes/determinants is air quality, which in turn derives from a complex multitude of causes/determinants. The presence of multiple and various sources of air pollution (indoor and environmental) and their relative contributions depend to a large extent on the social, economic and geographical local context. Hence there can be no 'one size fits all' strategy to deal with them; situation assessments are necessary.

Guiding Principles in Strategy Formulation

As a 'strategy' cannot be reduced to a shopping list of possible interventions, it is opted to formulate a number of guiding principles, not so abstract as to leave room for any interpretation, yet general enough to leave room for choices to be made as a function of local circumstances. These guiding principles are as follows.

In SSA – and a fortiori in the partner countries – 'safe air quality' is in the same class as 'safe water and sanitation' and 'adequate nutrition' as a necessary condition for the health of the public. Thus a constant concern with air quality in all of Enabel's actions is highly warranted.

Ensuring safe air quality requires the capacity to deal with messy and complex problems, involving health, ecology, empowerment of vulnerable groups in society, climate change, dealing with the challenges of living in ever-growing cities, etc.

Needed interventions range from generalized 'blanket' measures (applied nationwide) to locally tailored interventions, from the highly political to the purely technical. Although there is some consensus on the general direction to be followed, it is also clear that there is not one size to fit all situations.

Four types of preliminary analysis are needed (at different levels of decentralization):

- *Technology assessment*
- *Needs assessment (technically defined)*
- *Demand assessment (socially defined)*
- *Stakeholder assessment (vested interests, power)*

Given the level of complexity, the formation of a widely shared coherent discourse is indispensable. This is an essentially political process taking the form of a dialogue/debate informed by the forementioned assessments, centered on

- *A common understanding of public goods*
- *A forward-looking vision based on historical understanding of the present situation*
- *A vision of development that is adapted to present-day global, national and local challenges*[1]

[1] the number of vehicles per capita is not necessarily an adequate metric of 'development'

Notable differences can be expected between the categories *urban/peri-urban/rural*, to which additional layers can be added: industrial emissions, traffic density, power plant pollution, atmospheric dust, household produced smoke, waste disposal management, agriculture-based pollution, workplace and housing conditions, etc. Among other actions, reliable ground level monitoring stations are needed for continuous assessment of environmental air quality; on a less granular scale satellite observations can be used (e.g., ESA 5P satellite data: TROPOMI measures NO2 levels since June 2018).

Guiding Principles in Strategy Formulation (cont.)

At present, such discourse formation can best be structured along the language of the SDGs: (1) they are goals to which everyone subscribes and (2) they approximately cover all the many different (and potentially conflicting) areas that need to be taken into account.

The more local the action to be undertaken, the more it should be based on specific local needs and demand assessment. The aim should be to produce perceived improvement of the quality of life and of the perceived range of choices people have.

The health system and its actors should be expected to lead by example.

It should be noted that stakeholder inventories that have been made so far mainly focused on potential actors, that are positive to the cause of good quality air. It is to be expected that there will also be important stakeholders resisting any positive change toward cleaner air, for instance the fossil fuel and tobacco industries and people whose source of living involve fossil fuel / tobacco production; entities who have other priorities regarding economic development; etc.

It would be potentially very effective to utilise a *connecting discourse* promoting good air quality by incorporating all or most of these SDG issues (Table 6). Part of this narrative is to portray ***clean environmental air as a public good*** – hence the responsibility lies with public authorities – but from a pragmatic strategic point of view it might be useful to create a specific focus on *urban development*, as this is a geographic, ecological, demographic, social and economic challenge everywhere (that can also easily be linked to a social determinants narrative, especially in the area of household air pollution: access to clean energy depends to a large extent on people's social position in society).

Table 6.Connecting the SDG dots: a discourse

SDG #	The discourse
3 Strengthening of health systems and services to help ensure healthy lives and promote well-being for all at all ages	CRD frequency and severity are an established fact, but little attention has been given it so far in most SSA countries. Yet effective responses do exist and will be increasingly necessary in the short- and long-term future. Effective medical interventions in the healthcare system include relief of suffering and secondary prevention, i.e. control of exacerbations (asthma and COPD). Primary prevention measures include tobacco control, ensuring a safe workplace environment (see also SDG 8: 'decent work') and maintaining good air quality (indoor and outdoor) as a ***constant concern***.
5 Gender equality; bringing forth appropriate and adequate attention to women and children	In many SSA social environments, the tasks of cooking and fetching cooking fuel (wood, grass, etc) fall to women, often absorbing a lot of time. Time and effort involved in collecting fuel and cooking can be greatly reduced, i.e., by use of appropriate technology (cooking techniques) and sources of heat (see also SDG 7), thus increasing the range of choices for women to spend time differently. Increasing the space of choice is an important element of potential empowerment.
7 Access to affordable and clean energy sources	In the domain of *indoor air quality*, replacing solid fuels (and to a somewhat lesser extent kerosene) for cooking with clean(er) fuels like gas or biomass pellets/briquettes seems to be the only feasible and effective way to drastically improve indoor (kitchen) air quality and ensure subsequent health benefits (apart from the obvious adequate ventilation issue). The link with SDG 5 is clear as mostly women (and their small children) are the main group exposed to noxious indoor smoke and fumes. There is of course an equally important link with SDG 3 (health), for adults and also particularly for children, exposed as they are to the untoward effects of smoke starting from their foetal development and throughout the early years of life, crucial for pulmonary development and ultimate susceptibility to CRD and other conditions.

	Outdoor (environmental) *air quality* is as important for health as indoor air quality, but the decision spaces tend to lie outside that of the households (although indoor air pollution can significantly contribute to outdoor pollution). Especially in urban environments, this is linked to the concerns of SDG 11 (resilient and sustainable cities), where possible choices include clean electricity production (in practice this usually means getting rid of coal-fired / fossil fuel-powered plants), enforcement of acceptable emission standards for industrial development, and regulation of motorized transport (fuel and engine efficiency, as well as multiplication of individualised motorised transport). Not only fuel efficiency is important, but also its inherent potential to pollute (most visibly maybe diesel fuel with unacceptably high sulphur content).
8 Specifically, the right to *decent work*	Reaching this goal requires acceptably safe working conditions and environments, including the air that workers breathe, in formal and informal industry, agriculture and service sectors – a potentially very wide field of application. It might be added that also household cooking is 'work' that deserves to be 'decent', linking SDG 8 to SDGs 5 (gender empowerment) and SDG 7 (affordable clean energy).
11 Sustainable cities and communities	This is a highly complex matter, but certainly also involving good environmental air quality. It may be pertinent to draw attention to the fact that in SSA, urbanisation is not only about 'mega-cities' as poles of attraction but also (and sometimes mainly) about the growth of medium-sized agglomerations. Maintaining acceptably clean environmental and household air in all these circumstances requires continuous attention. The spontaneous, usually disorderly and unplanned growth of urban settlements mainly creates peripheral growth areas for new arrivals, where energy and water and sanitation services are absent or nearly so. In such circumstances household air pollution is likely to contribute very significantly to outdoor pollution; access to affordable clean energy sources (SDG 7) is therefore a major concern. Furthermore, expanding cities (big and smaller ones) depend on surrounding rural or semi-rural environments to provide them with energy (be it in the form of food or fuel). If new arrivals continue to make use of solid fuels (like wood or charcoal), these have to come from somewhere, further taxing already fragile environments (like forests, cf. SDG 15: sustainably manage forests). Economically speaking, the whole point of cities is the increased potential for exchange, in terms of intensity and diversity. This requires mobility; the bigger the city, the more this mobility requires (speedy) transport; speedy transport requires motorisation, and motorisation requires energy. Thus, the growth of cities links to the availability of clean energy (SDG 7), not only at household level but also generally.
12 Sustainable consumption and production, and the promotion of renewable energy.	In the first place this means reducing the use of fossil fuels (but also of insufficiently renewable other solid fuels like wood), and calls for diversification of energy sources, including hydro-electric, solar, wind and geothermal energy. Depending on the situation, this may require (and almost certainly does) de-subsidising and subsidising measures. The ultimate goal is not in the first place to expand energy sources (with renewables) but to replace fossil fuels as much as possible. The link with SDG 7 (clean energy) is obvious.
13 Combatting climate change.	The link with SDG 12 and SDGs 7 (clean energy) and 11 (sustainable cities) seems clear. In the end, also SDG 3 (health/well-being) is linked to climate change. Clean air appears to occupy a central place in all these development goals. Similarly, **SDG 13** (specifically sustainably manage forests) automatically links to resilient and sustainable cities (SDG 11), renewable energy (SDG 13) and clean energy (SDG 7).
A *constant concern with clean air* appears to be one of the most basic necessary attitudes, at household, local community and general policy levels.	

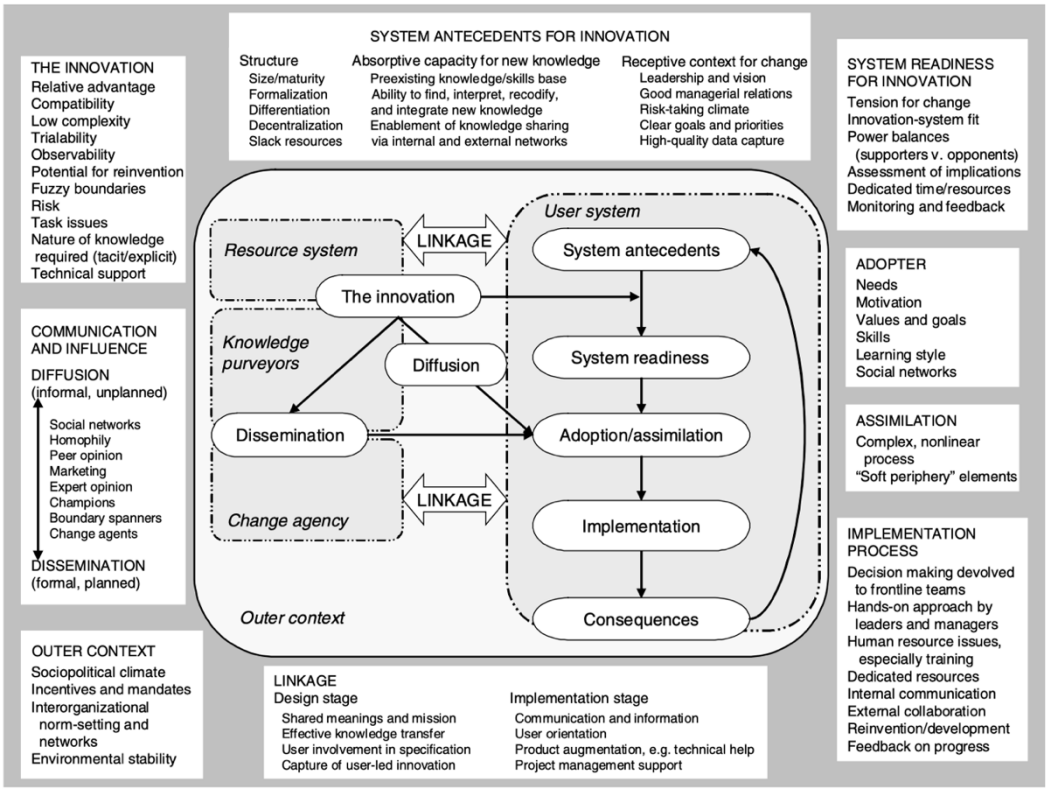
B. STAKEHOLDER ENGAGEMENT

> "***If you want to go fast, go alone. If you want to go far, go together.***"
>
> \- Old African proverb

It is best to engage the different stakeholders on the actions that are planned to be undertaken as early as possible. Beyond analysing the positions and levels of influence of the people/population, organizations, and authorities that will affect and be affected by the interventions (i.e., conducting a stakeholder analysis), stakeholders can be involved [1] in determining what strategies would be appropriate (co-development and shared decision-making), [2] in instituting the necessary contextual adaptations and [3] in the implementation of the interventions, and [4] given the chance to co-design contextualised actions. Stakeholder engagement will favour acceptance, ownership and possibly lead towards more successful outcomes from the planned interventions.

The theory of Greenhalgh *et al.*[218] regarding adoption of any intervention by service organizations can be applied in engaging stakeholders. Greenhalgh and colleagues noted that adoption is variable whereby some interventions may be fully adopted, partially or not at all, while some may be eventually abandoned in time; and they proposed a unifying conceptual model for considering the different aspects of a complex situation and their many interactions (Figure 10). Certain attributes influence the (non)adoption of interventions based on the characteristics of the proposed intervention, the individuals who will adopt the intervention and the system where it will be assimilated. Characteristics of any interventions planned to be implemented - relative advantage, compatibility, simplicity, trialability, observability, reinvention, risk, consideration of task issues, knowledge required, and augmentation/support - can be (pre)determined together with the stakeholders. While this will not assure 100% adoption and zero abandonment, it may increase adoption with eventual sustainability, spread and scale-up.

Figure 10.Greenhalgh et al.'s Conceptual Model for considering the Determinants of Diffusion, Dissemination and Implementation of Innovations in Health Systems Delivery and Organization[223].



[218] Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q* 2004; 82: 581-629

CHAPTER VIII

CONCLUSIONS & WAYS FORWARD

Chronic respiratory disease, although a health problem deserving to be tackled in its own right, cannot be divorced from its causes and determinants, among which unsafe air quality ranks highest.

In its turn, air quality is determined by a multitude of causes and itself determines a multitude of untoward effects – not only in terms of chronic respiratory conditions, but also in terms of cardiovascular disease, cancer, and acute respiratory illness. Furthermore, air quality is, directly or indirectly but most often strongly, linked to problems of environmental degradation, climate change, empowerment of vulnerable population groups (i.e., gender issues), viability of urban agglomerations, acceptable working conditions, transition to renewable energy sources and other issues.

In other words, adequately tackling chronic respiratory diseases (the initial starting point of this note) opens up a whole range of parallel and linked issues requiring multiple entry-points into understanding the problem and logically leading to the need to act in concert with a number of persons and organisations mastering different and complementary competences.

Forging a coalition of such individuals and organisations, and creating a common coherent language of description, understanding and action for the future may well be a preliminary condition for effective action in the future.

The challenge appears to be urgent. Circumstances on the African continent are such that at present air quality is already among the worst on the planet, and further deterioration – and its consequences – is inevitable if adequate action is not undertaken. Clearly, henceforth this issue deserves to be a constant concern for international cooperation agencies like Enabel in dealing with Belgium's African partner countries.