**Clinical algorithm to screen for cardiopulmonary disease in low-income settings**

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Africa faces many health challenges, many of which are unique to the continent. Although rarely considered an important contributor to premature death in high-income countries, cardiopulmonary disease (CPD) is, for a number of reasons, a common condition affecting Africans at a young age. In addition to recognizing CPD as an important condition, we outline a pragmatic screening protocol for identifying CPD in the African context.

Any attempts to understand the burden of disease in sub-Saharan Africa are doomed to failure if viewed through the prism of experiences in high-income countries. This situation is particularly evident when considering the limited capacity and resources to diagnose complex diseases in many parts of this region. This critical limitation is exacerbated when the complex conditions remain poorly characterized on a global basis. In this Comment article, we outline the conundrum of screening for and diagnosing cardiopulmonary disease (CPD) in the African context on the basis on the following definition: a broad spectrum of conditions concurrently affecting the heart and lungs that ranges from those at high risk of developing right heart failure and death owing to the presence of largely asymptomatic, mild-to-moderate pulmonary hypertension that represents latent CPD, to those who have already developed concurrent and symptomatic lung and/or cardiac pathology that represents established CPD.

**[H1] The African context**

Continental Africa is home to a considerable proportion of the poorest billion people worldwide and remains far from achieving many developmental targets linked to better health and longevity1. Rapid urbanization and an accelerated process of epidemiological transition2 have triggered the emergence of new patterns of risk behaviours and health challenges that are unique to the continent, the major feature of which is a deadly confluence between endemic communicable disease (including tuberculosis, HIV infection and schistosomiasis) with emergent non-communicable diseases in those who survive early childhood in poverty3. A range of socioeconomic, health service and environmental factors (from chronic exposure to indoor air pollution to minimal primary health care) underlie these unique pathways to complex disease. Unfortunately, funding initiatives predominantly focused on HIV, malaria and other infectious diseases indirectly undermine efforts to highlight and address the importance of complex disease and the priorities of primary prevention.

**[H1] Cardiac and pulmonary disease in Africa**

Until the Heart of Soweto Study4 focusing on the large urban African enclave of Soweto in South Africa was completed a decade ago, it was incorrectly assumed both that, beyond documented high levels of hypertension, heart disease was scarce among Africans and that, aside from specific conditions (such as idiopathic cardiomyopathy), emergent heart disease would largely follow the same pattern as had been observed in high-income countries5. The Heart of Soweto Study4 demonstrated that heart disease in Africa was different from that in other regions, affecting both younger individuals and a higher proportion of women. Moreover, unlike a distinctive predominance of left heart disease in other parts of the world, a surprisingly high number individuals presented with right heart failure6. Overall, of the 2,505 de novo cases of heart disease, 28% were diagnosed with right heart failure, with more women affected than men. Contributing factors were many and varied, with primary pulmonary disease — including chronic obstructive pulmonary disease and higher rates of smoking — more evident among men, and more pulmonary hypertension and rheumatic heart disease evident among women6. Subsequently, the Pan-African Pulmonary Hypertension Cohort Study7, prospectively demonstrated a similar pattern of antecedent disease as well as a poor prognosis (21% mortality at 6 months) associated with often insidious right heart failure . As such, clear opportunities to improve the prevention, treatment and management of pulmonary hypertension and other forms of disease concurrently affecting the heart and lungs (that is, CPD) were evident7.

**[H1] Preventing and diagnosing CPD in Africa**

The gulf in diagnostic resources between high-income and low-income countries is particularly acute in the southern African country of Mozambique. Mozambique is one of the poorest counties in the world, and emergency department disease surveillance in three geographically different regions of the country has confirmed a confluence of cardiac and respiratory diseases in the form of CPD. Of note, a concerning pattern of transition from respiratory disease to CPD was observed among children to adults8. This phenomenon might be at least partially related to chronic exposure to indoor air pollution, schistosomiasis and other poverty-related environmental and/or occupational hazards, leading to interstitial and vascular pulmonary disease and resulting in pulmonary hypertension, right heart strain and potential progression to cor pulmonale. Common left heart diseases with reduced ventricular ejection fraction (such as dilated cardiomyopathy and peripartum cardiomyopathy), diastolic dysfunction (severe uncontrolled systemic hypertension) or abnormal valve function (rheumatic heart disease) often result in pulmonary oedema and subsequent poor lung compliance. Multifactorial CPD is further exacerbated by a high occurrence of pulmonary tuberculosis, sickle cell disease and endomyocardial fibrosis in certain regions. Moreover, an evolving HIV epidemic has triggered new pathways to CPD via immunosuppression and opportunistic infections, cardiac dysfunction linked to HIV-related cardiomyopathy, transplacental exposure to drugs such as zidovudine (known to affect fetal cardiac development) and primary pulmonary hypertension9. However, owing to a shortage of human and material resources to screen for and diagnose complex disease, CPD remains an underappreciated contributor to poor health outcomes. Reflecting this lack of focus on CPD as a distinct entity, it remains ill-defined in clinical practice.

**[H1] Pragmatic screening for CPD in Africa**

In these circumstances, to generate critical insights into the individual, socioeconomic and environmental drivers of the burden and natural history of CPD in Africa, we formed the Socio-Economic and Environmental Antecedents to Reveal the Cardiopulmonary Heart of Africa (SEARCH-AFRICA) collaboration. One of the first tasks of this collaboration was to define clearly the broad characteristics and spectrum of CPD observed in Africa, with consideration of contemporary data on the development and effects of right heart disease, particularly in the setting of pulmonary hypertension. With specific reference to the observed pattern of CPD in Africa to date, together with a newly identified threshold for high risk of premature death associated with often silent and untreated pulmonary hypertension10we developed the practical definition of CPD outlined earlier in the introduction.

To then detect CPD in the emergency departments of Mozambique (and other low-income countries in Africa) with limited resources, we have developed a staged and pragmatic screening algorithm to detect both latent and established CPD among individuals aged ≥15 years (FIG. 1). As with other algorithms developed for low-income settings, the risk profile and disease pattern, as well as the availability of trained health professionals, diagnostic means and patient referral pathways within the health system, have been taken into account. This algorithm considers the individual’s clinical presentation, clinical history and home environment to identify those at moderate-to-high risk of CPD. These individuals are then subject to a combination of 6-min walking test (6MWT), chest radiography, spirometry and cardiac ultrasonography for more definitive identification and classification of CPD. In the context of a scarcity of specialists and invasive diagnostics, this pragmatic algorithm is designed to facilitate standardized screening and characterization of the individuals using all types of health-care professionals — from those readily available who can be trained to perform front-line evaluation and assess risk (such as nurses, clinical officers and general practitioners) to specialists who can confirm the diagnosis in patients previously assessed as being at high risk (such as physicians, cardiologists and pneumologists) — while purposefully and progressively applying more complex and expensive diagnostic options.

Past and/or present high-risk socioeconomic, familial and environmental risks (including passive or primary smoking and lifestyle behaviours) as well as medical history and physical examination (including World Health Organization functional class assessment on the basis of a 6MWT are the starting point of our screening. Given that indoor air pollution is almost ubiquitous in most peri-urban and rural settings in Africa, thorough assessment of the type, level, intensity and pattern of exposure is mandatory; this assessment might include household visits and/or the use of personal and fixed air-quality monitors. Spirometry is used to measure the forced expiratory volume in 1 s (FEV1) and the forced vital capacity (FVC) to confirm the presence and stage of chronic obstructive pulmonary disease, using the percentage of the predicted FEV1 and the Tiffeneau–Pinelli index (FEV1/FVC). Finally, echocardiography is performed to detect structural abnormalities, assess cavity dimensions, estimate or measure pulmonary pressure using tricuspid regurgitation, determine filling pressures and assess ventricular function.

**[H1] Conclusions**

To validate and refine this clinical algorithm and generate other important insights into the drivers of the burden and natural history of CPD in Africa, we plan to undertake an interdisciplinary and highly collaborative study of the causes and consequences of CPD in Mozambique. The appropriately named SEARCH-AFRICA project will recruit and profile a large cohort of individuals presenting to sentinel emergency departments (often the only point of contact with health services) servicing vulnerable African communities in Mozambique. The project will also expand surveillance into the community setting to explore the socioeconomic and environmental determinants of CPD.

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**Competing interests**

The authors declare no competing interests.

Fig. 1 | **A pragmatic algorithm to screen for cardiopulmonary disease in Africa.** BNP, B‑type natriuretic peptide; CMO, cardiomyopathy , COPD, chronic obstructive pulmonary disease; CPD, cardiopulmonary disease; FEV1, forced expiratory volume in 1 s; FVC, forced volume capacity; HF, heart failure; mPAP, mean pulmonary arterial pressure; PHT, pulmonary hypertension; SBP, systolic blood pressure.

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