Cancer in sub-Saharan Africa: a *Lancet Oncology* Commission

Wilfred Ngwa, Beatrice W Addai, Isaac Adewole, Victoria Ainsworth, James Alaro, Olusegun I Alatise, Zipporah Ali, Benjamin O Anderson, Rose Anorlu, Stephen Avery, Prebo Barango, Noella Bih, Christopher M Booth, Otis W Brawley, Jean-Marie Dangou, Lynette Denny, Jennifer Dent, Shekinah N C Elmore, Ahmed Elzawawy, Diane Gashumba, Jennifer Geel, Katy Graef, Sumit Gupta, Serigne-Magueye Gueye, Nazik Hammad, Laila Hessissen, Andre M Ilbawi, Joyce Kambugu, Zisis Kozlakidis, Simon Manga, Lize Maree, Sulma I Mohammed, Susan Msadabwe, Miriam Mutebi, Annet Nakaganda, Ntokozo Ndlovu, Kingsley Ndoh, Jerry Ndumbalo, Mamsau Ngoma, Twalib Ngoma, Christian Ntizimira, Timothy R Rebbeck, Lorna Renner, Anya Romanoff, Fidel Rubagumya, Shahin Sayed, Shivani Sud, Hannah Simonds, Richard Sullivan, William Swanson, Verna Vanderpuye, Boateng Wiafe, David Kerr

In sub-Saharan Africa (SSA), urgent action is needed to curb a growing crisis in cancer incidence and mortality. Without rapid interventions, data estimates show a major increase in cancer mortality from 520 348 in 2020 to about 1 million deaths per year by 2030. Here, we detail the state of cancer in SSA, recommend key actions on the basis of analysis, and highlight case studies and successful models that can be emulated, adapted, or improved across the region to reduce the growing cancer crises. Recommended actions begin with the need to develop or update national cancer control plans in each country. Plans must include childhood cancer plans, managing comorbidities such as HIV and malnutrition, a reliable and predictable supply of medication, and the provision of psychosocial, supportive, and palliative care. Plans should also engage traditional, complementary, and alternative medical practices employed by more than 80% of SSA populations and pathways to reduce missed diagnoses and late referrals. More substantial investment is needed in developing cancer registries and cancer diagnostics for core cancer tests. We show that investments in, and increased adoption of, some approaches used during the COVID-19 pandemic, such as hypofractionated radiotherapy and telehealth, can substantially increase access to cancer care in Africa, accelerate cancer prevention and control efforts, increase survival, and save billions of US dollars over the next decade. The involvement of African First Ladies in cancer prevention efforts represents one practical approach that should be amplified across SSA. Moreover, investments in workforce training are crucial to prevent millions of avoidable deaths by 2030. We present a framework that can be used to strategically plan cancer research enhancement in SSA, with investments in research that can produce a return on investment and help drive policy and effective collaborations. Expansion of universal health coverage to incorporate cancer into essential benefits packages is also vital. Implementation of the recommended actions in this Commission will be crucial for reducing the growing cancer crises in SSA and achieving political commitments to the UN Sustainable Development Goals to reduce premature mortality from non-communicable diseases by a third by 2030.

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See **Comment** pages 701, 702, 703, 705, 706, and 708

Introduction

The challenge of cancer now faced by sub-Saharan Africa (SSA) is enormous and is likely to worsen rapidly if adequate measures are not taken.[1] This Commission was created to inquire into, describe, and analyse the state of cancer in SSA, and recommend key actions to address the growing challenge. The COVID-19 pandemic has already made the situation worse,[2–4] highlighting weaknesses in health-care systems, and the need for increased urgency for action by African governments, the African Union, and other stakeholders. Communicable, maternal, nutritional, and perinatal diseases have long been the main drivers of morbidity and mortality in SSA. Through concerted efforts to control these diseases, coupled with improvements in the general standard of living, a seismic shift is happening across the subcontinent's epidemiological landscape, with a rising incidence of non-comunicable diseases (NCDs) such as cancer. In 2018, the International Agency for Research on Cancer (IARC) reported that 693 487 Africans would die from cancer that year with a predicted increase to 1 429 812 deaths by 2040.[5,6] This number represents a predicted 106% increase (ie, more than doubling) in deaths between 2018 and 2040. For SSA in particular, the past 30 years also saw a doubling in cancer incidence.[7,8] Without intervention, experts predict that these numbers could double again in only 20 years, corresponding to a doubling of cancer deaths in Africa (figure 1).[9]

Africa's cancer explosion is attributable to external and internal factors, including infection, changing population demographics, behavioural changes, environmental exposures, and genetics. In Africa, cancers associated with infections, including liver cancer (hepatitis B and C viruses), cervical cancer (human papillomavirus), and Kaposi sarcoma (human herpesvirus 8), comprised 27% of all incident cancers in 2018—the highest percentage of any WHO region.[10] High rates of HIV infection across SSA have also resulted in a high incidence of HIV-associated malignancies such as Kaposi sarcoma, cervical cancer, and non-Hodgkin lymphoma. Despite reductions in HIV-related deaths due to the scale-up of antiretroviral therapy, HIV-associated malignancies have not shown a concomitant drop in incidence.[11–13] Meanwhile, the African continent has entered a demographic transitional period marked by an increase in the average life expectancy and thus the percentage of the older population who are more predisposed to malignancies.[14] This transition has been accompanied by increasing adoption of so-called westernised lifestyles (eg, physical inactivity and consumption of processed or unhealthy foods, alcohol, and

Brigham and Women's Hospital, Dana-Farber Cancer Institute, Harvard Medical School, Boston, MA, USA (Prof W Ngwa PhD); **Sidney Kimmel Comprehensive Cancer Center, School of Medicine** (Prof W Ngwa, Prof O W Brawley MD) **and Department of Epidemiology, Bloomberg School of Public Health** (Prof O W Brawley), **Johns Hopkins University, Baltimore, MD, USA; Department of Information and Sciences, ICT University, Yaoundé, Cameroon** (Prof W Ngwa); **Breast Care International, Peace and Love Hospital, Kumasi, Ghana** (B W Addai MD); **College of Medicine, University of Ibadan, Ibadan, Nigeria** (Prof I Adewole MD); **Department of Physics and Applied Physics, University of Massachusetts Lowell, Lowell, MA, USA** (V Ainsworth BSc); **National Cancer Institute, National Institute of Health, Bethesda, MD, USA** (J Alaro PhD); **Department of Surgery, Obafemi Awolowo University, Ile Ife, Nigeria** (Prof O I Alatise MD); **Kenya Hospices and Palliative Care Association, Nairobi, Kenya** (Z Ali MD); **Division of Public Health Sciences, Fred Hutchinson Cancer Research Center, Seattle, WA, USA** (Prof B O Anderson MD); **Department of Obstetrics and Gynaecology, College of Medicine, University of Lagos, Lagos University Teaching Hospital, Lagos, Nigeria** (Prof R Anorlu MD); **Department of Radiation Oncology, Perelman School of Medicine,**

University of Pennsylvania, Philadelphia, PA, USA (S Avery PhD); WHO, Regional Office for Africa, Brazzaville, Republic of the Congo (P Barango MD, J-M Dangou MD); Dana-Farber Cancer Institute, Harvard Medical School, Boston, MA, USA (N Bih BSc); Division of Cancer Care and Epidemiology, Cancer Research Institute (Prof C M Booth MD) and Department of Oncology (N Hammad MD), Queen's University, Kingston, ON, Canada; Department of Obstetrics and Gynaecology, University of Cape Town, Cape Town, South Africa (Prof L Denny MD); BIO Ventures for Global Health, Seattle, WA, USA (J Dent MBA, K Graef PhD); Department of Radiation Oncology, School of Medicine, University of North Carolina, Chapel Hill, NC, USA (S N C Elmore MD, S Sud MD); Department of Clinical Oncology, Suez Canal University, Ismailia, Egypt (Prof A Elzawawy MD); Ministry of Health, Kigali, Rwanda (D Gashumba MD); Division of Paediatric Haematology and Oncology, Faculty of Health Sciences, School of Clinical Medicine (Prof J Geel MD) and Department of Nursing Education (L Maree RN), University of the Witwatersrand, Johannesburg, South Africa; Division of Hematology/Oncology, The Hospital for Sick Children, Toronto, ON, Canada (S Gupta MD); Urology Department, Idrissa Pouye General Hospital, Dakar, Senegal (Prof S-M Gueye MD); Pediatric Oncology Department, Pediatric Teaching Hospital, Rabat, Morocco (Prof L Hessissen MD); Department of Non-communicable Diseases, WHO, Geneva, Switzerland (A M Ilbawi MD; Prof B O Anderson); Department of Pediatrics, Uganda Cancer Institute, Kampala, Uganda (J Kambugu MD); Laboratory Services and Biobank Group, International Agency for Research on Cancer, WHO, Lyon, France (Z Kozlakidis PhD); Cameroon Baptist Convention Health Services, Bamenda, Cameroon (S Manga PhD); Department of Comparative Pathobiology, Center for

tobacco), which are well documented as a key contributor to the increase in cancer incidence.[15,16] As the prevalence of obesity in SSA has increased, so too have malignancies associated with obesity, such as breast, cervical, and colorectal cancers.[15,16] Tobacco use—although not as prevalent in SSA as in other global regions—is attributed to a substantial percentage of deaths due to lung, tracheal, bronchial, and oral cancers.[8,17,18] With respect to environmental factors, it is well known that countries within SSA depend, to varying degrees, on agro-allied and mineral extractive industries, which are all associated with increased exposures to known carcinogens such as pesticides, mercury, hazardous chemicals, and polluted air. Although understanding of the effect of environmental exposures to carcinogens in SSA, including from occupational sources, is incomplete, available data indicate correlations between environmental exposures common to SSA and increased incidence of specific cancer types.[19,20]

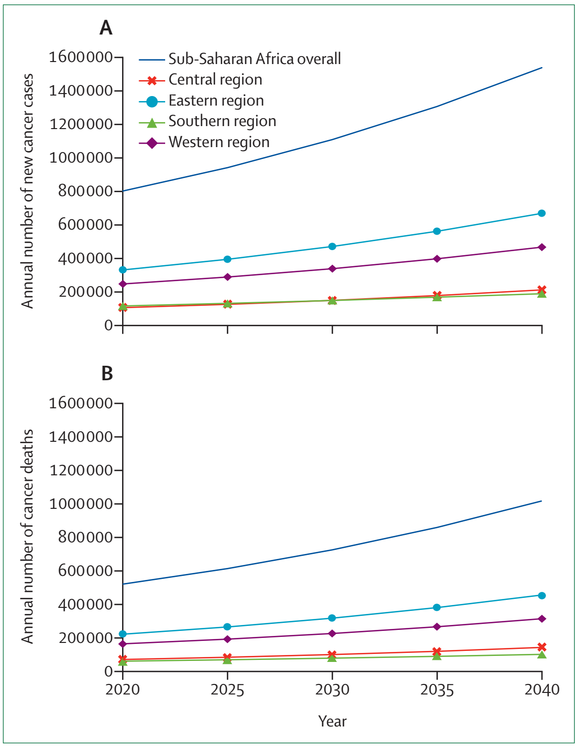


Figure 1: **Cancer incidence and mortality over time (2020–40) by sub-Saharan Africa sub-region**

Beyond external drivers of oncogenesis, tumour biology and genetics are also attributed to the disproportionate effect of many cancers on individuals of African descent.[21,22] Studies have reported unique genetic characteristics in Africans that modulate their risks to specific cancer types, particularly breast and prostate cancers. These genetic markers modulate the clinical manifestation of these malignancies, such as in a predisposition of African women to be diagnosed with breast cancer at a younger age than their White counterparts, and prostate cancer incidence rates being disproportionately higher in men of African descent than in other ethnicities.[23,24]

The cancer situation in Africa relative to other WHO regions underscores the serious situation and need for an Afro-centric approach. Compared with other regions of the world, SSA's cancer incidence rate (128·2 per 100 000) is higher than that found in low (115·7) and medium (108·5) human development index (HDI) regions.[9,25] The incidence of different cancer types varies between SSA and high HDI regions worldwide (tables 1, 2). Although cervical cancer, a HIV-related malignancy, ranks the second highest in cancer incidence in SSA, it ranks 20th in very-high HDI regions. Conversely, lung cancer, which ranks second in incidence in very-high HDI countries, ranks 11th in SSA and stomach cancers, which rank fifth in incidence in very-high HDI countries, rank 10th in SSA. Despite the substantially high cancer incidence rates in very-high HDI regions, the mortality rate due to cancer in SSA (87·1 per 100 000 people) is close to the mortality rate in very-high HDI regions (98·7; table 2).[9] The substantial difference in the mortality-to-incidence ratio in SSA (0·7) compared with very-high HDI regions (0·3; calculated from table 2) underscores the crucial challenges that the African sub-continent faces in successfully detecting, diagnosing, and treating patients with cancer. Unlike very-high HDI regions, which are predicted to see an increase in cancer incidence of 33% by 2040, cancer incidence in SSA is estimated to nearly double along with deaths within the same time period.[9] Beyond the loss of life caused by cancer, governments must recognise the financial toll that malignancies have on the economy (table 3) and use these statistics to argue for appropriate

	All ages					**Ages 0–14 years**				
	Sub-Saharan Africa	Central Africa	Eastern Africa	Southern Africa	Western Africa	Sub-Saharan Africa	Central Africa	Eastern Africa	Southern Africa	Western Africa
Incidence (age-standardised rate worldwide per 100 000 people)										
All sexes	128·2	111·1	130·2	202·4	111·5	8·6	7·6	10·0	8·1	7·5
Males	119·4	109·6	112·9	232·7	100·6	9·3	8·4	10·9	8·7	8·1
Females	139·0	115·8	148·0	188·9	123·2	7·8	6·8	9·1	7·5	6·8
New cases in 2020	801 702	106 467	331 233	116 391	247 611	39 400	6185	18 640	1597	12 978

(Table 1 continues on next page)

	All ages					Ages 0–14 years				
	Sub-Saharan Africa	Central Africa	Eastern Africa	Southern Africa	Western Africa	Sub-Saharan Africa	Central Africa	Eastern Africa	Southern Africa	Western Africa
(Continued from previous page)										
Highest incidence cancers (all sexes, % of total cancer incidence)										
Bladder	1·8	1·3	2·1	1·9	1·7	0·6	0·3	0·6	0·4	0·7
Brain, central nervous system	1·1	0·8	1·1	0·8	1·5	5·6	3·1	4·7	7·8	7·7
Breast	16·1	16·8	13·8	14·2	19·9	0·2	<0·1	0·2	0·4	0·2
Cervical	13·8	14·7	16·5	10·6	11·2	0·1	··	0·1	0·3	0·1
Colorectal	5·7	5·4	5·5	6·6	5·5	0·2	0·1	0·3	0·3	0·3
Endometrial	1·3	0·9	1·1	2·0	1·4	··	··	··	··	··
Head and neck	3·9	4·5	4·0	3·7	3·6	3·2	3·2	3·4	1·9	3·0
Hodgkin lymphoma	0·9	0·6	0·9	0·6	1·1	3·4	2·5	4·2	4·1	2·6
Kaposi sarcoma	3·1	2·3	4·7	4·0	0·8	2·4	0·8	3·8	5·6	0·6
Kidney	1·6	1·5	1·7	1·2	1·8	13·5	15·9	14·5	14·2	10·8
Leukaemia	2·7	2·4	3·2	1·7	2·4	13·9	10·2	16·7	18·9	11·1
Liver	4·8	5·7	3·7	2·2	7·1	2·4	3·2	2·4	3·1	1·8
Lung	2·8	1·9	2·2	7·9	1·7	0·1	··	0·1	0·9	0·2
Multiple myeloma	0·7	1·0	0·6	1·6	0·4	0·3	0·3	0·3	0·5	0·2
Non-Hodgkin lymphoma	4·5	4·7	4·7	3·2	4·8	16·7	25·8	17·0	9·5	12·9
Oesophageal	3·0	2·0	4·9	3·1	1·0	<0·1	··	<0·1	··	<0·1
Ovarian	2·2	2·1	2·2	1·4	2·7	1·1	0·8	0·9	2·1	1·3
Pancreas	1·3	1·2	1·2	1·8	1·5	<0·1	··	<0·1	··	0·1
Prostate	9·6	12·6	7·1	12·0	10·7	<0·1	··	<0·1	0·1	··
Stomach	2·9	3·1	3·0	1·6	3·2	0·3	0·1	0·5	··	0·2
Thyroid	1·2	0·7	1·7	1·2	0·8	0·3	0·1	0·3	0·4	0·4
Mortality (age-standardised rate worldwide per 100 000 people)										
All sexes	87·1	78·4	92·1	109·0	78·8	4·7	4·2	5·6	2·9	4·2
Males	83·6	79·2	82·4	128·8	74·7	5·1	4·6	6·0	3·2	4·6
Females	92·2	79·9	102·4	98·7	83·6	4·4	3·8	5·2	2·7	3·9
Total deaths in 2020	520 348	71 570	222 189	61 659	164 930	21 726	3397	10 438	579	7312
Highest mortality cancers (all sexes, % of total cancer deaths)										
Bladder	1·5	1·1	1·8	1·4	1·5	0·6	0·4	0·6	0·3	0·8
Brain, central nervous system	1·5	1·0	1·4	1·2	1·8	7·0	4·0	5·8	13·3	9·5
Breast	12·4	13·3	10·8	8·3	15·5	0·2	<0·1	0·2	<0·1	0·2
Cervical	14·0	14·8	16·4	11·1	11·4	0·1	··	0·1	<0·1	0·1
Colorectal	6·0	5·9	6·0	6·4	6·0	0·3	0·1	0·3	<0·1	0·3
Head and neck	3·8	4·5	4·0	3·4	3·5	3·2	3·3	3·4	0·9	3·0
Hodgkin lymphoma	0·6	0·4	0·6	0·3	0·8	2·7	2·3	3·3	1·4	2·2
Kaposi sarcoma	2·5	2·0	4·1	1·9	0·7	2·2	0·9	3·7	2·8	0·7
Kidney	1·6	1·5	1·6	1·1	1·8	13·4	15·7	14·8	7·8	10·8
Leukaemia	3·1	2·8	3·6	2·5	2·7	13·5	10·0	16·0	27·3	10·4
Liver	7·0	8·0	5·2	4·0	10·2	3·0	4·2	3·0	3·3	2·2
Lung	3·9	2·7	3·0	12·9	2·3	0·1	··	0·1	0·2	0·2
Multiple myeloma	0·4	0·7	0·4	0·8	0·2	0·3	0·2	0·3	0·2	0·2
Non-Hodgkin lymphoma	4·4	4·4	4·5	3·2	4·7	15·1	22·9	15·3	9·3	11·5
Oesophageal	4·4	2·8	6·8	5·6	1·4	<0·1	··	<0·1	··	<0·1
Ovarian	2·4	2·3	2·4	1·7	2·9	0·9	0·7	0·8	0·2	1·1
Pancreas	2·0	1·7	1·7	3·3	2·2	<0·1	··	<0·1	··	0·1
Prostate	7·7	10·8	5·9	6·9	9·0	<0·1	··	<0·1	<0·1	··
Stomach	3·9	4·2	3·9	2·6	4·2	0·4	0·1	0·5	··	0·2

Table 1: **Sub-Saharan Africa cancer statistics—2020 incidence and mortality**[9,25]

Cancer Research, Purdue University, West Lafayette, IN, USA (Prof S I Mohammed PhD); **Department of Radiation Therapy, Cancer Diseases Hospital, Lusaka, Zambia** (S Msadabwe MD); **Department of Surgery** (M Mutebi MD) **and Department of Pathology** (S Sayed MD), **Aga Khan University Hospital, Nairobi, Kenya; Uganda Cancer Institute, Kampala, Uganda** (A Nakaganda MPH); **Faculty of Medicine and Health Sciences, University of Zimbabwe, Harare, Zimbabwe** (N Ndlovu MD); **Department of Global Health, University of Washington, Seattle, WA, USA** (K Ndoh MD); **Ocean Road Cancer Institute, Dar es Salaam, Tanzania** (J Ndumbalo MD, M Ngoma MD); **Department of Clinical Oncology, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania** (Prof T Ngoma MD); **African Centre for Research on End-of-Life Care, Kigali, Rwanda** (C Ntizimira MD); **Dana-Farber Cancer Institute, Harvard T H Chan School of Public Health, Boston, MA, USA** (Prof T R Rebbeck PhD); **Department of Paediatrics, University of Ghana School of Medicine and Dentistry, Accra, Ghana** (Prof L Renner MD); **Department of Health System Design and Global Health, Icahn School of Medicine, The Mount Sinai Hospital, New York, NY, USA** (A Romanoff MD); **Department of Oncology, Rwanda Military Hospital, Kigali, Rwanda** (F Rubagumya MD); **University of Global Health Equity, Kigali, Rwanda** (F Rubagumya); **Division of Radiation Oncology, Tygerberg Hospital and University of Stellenbosch, Stellenbosch, South Africa** (Prof H Simonds MD); **Institute of Cancer Policy, King's College London, London, UK** (Prof R Sullivan PhD); **Department of Physics and Applied Physics, Dana-Farber Cancer Institute, University of Massachusetts Lowell, Lowell, MA, USA** (W Swanson MS); **National Centre for Radiotherapy, Oncology, and Nuclear Medicine, Korle Bu Teaching Hospital, Accra, Ghana** (V Vanderpuye MD); **Watborg Eye Services, Obutu, Ghana** (B Wiafe MD); **Radcliffe Department of Medicine,**

John Radcliffe Hospital, University of Oxford, Oxford, UK (Prof D Kerr MD); **South African Medical Research Council, Gynaecological Cancer Research Centre, Tygerberg, South Africa** (Prof L Denny)

Correspondence to:
Prof Wilfred Ngwa, Sidney Kimmel Comprehensive Cancer Center, School of Medicine, Johns Hopkins University, Baltimore, MD 21231, USA
wngwa1@jhmi.edu

See **Online** for appendix

cancer budgets to ensure that national cancer control plans (NCCPs) are developed or implemented. Notably, unlike in the USA and Europe, cancer affects women more than men in SSA, with the age-standardised incidence rate of cancer per 100 000 women at 139·0 compared with 119·4 per 100 000 men.[9]

Meanwhile, within SSA, the overall incidence rates of cancer vary from country to country, as do the incidence rates of individual cancers. For example, eastern Africa has a higher incidence of oesophageal cancers, whereas southern Africa has more lung cancer compared with other regions (table 1). In children (aged 0–14 years), the cancer incidence rate is 8·6 per 100 000 children, with non-Hodgkin lymphoma, leukaemia, and kidney cancers comprising 44% of new cases (table 1). Disparities in cancer outcomes within the SSA sub-continent are also present, with less prosperous economies (as measured by their gross domestic product [GDP] per capita) facing substantially higher mortality-to-incidence ratios than their wealthier neighbours (appendix p 15).

Importantly, there are limitations to the conclusions that can be drawn from these data due to the scarce availability of population-based cancer registries (PBCRs) in Africa. Due to the absence of PBCRs, African countries' cancer data are often extrapolated from neighbouring countries or calculated on the basis of local registry data.[27] Beyond the absence of PBCRs, the underdiagnosis of cancer cases—which stems from a lack of appropriate diagnostic infrastructure and delayed or absent health-care-seeking behaviours by patients with cancer—is common in Africa. These limitations combined strongly suggest that the burden of cancer in SSA is higher than reported and demands priority action, including the key actions presented in this report.

	Sub-Saharan Africa	Low HDI regions	Medium HDI regions	High HDI regions	Very-high HDI regions
Age-standardised rate worldwide per 100 000 people					
All sexes	128·2	115·7	108·5	190·5	295·3
Males	119·4	104·3	109·2	207·6	335·3
Females	139·0	128·0	108·7	178·0	267·6
New cases in 2020	801 702	650 423	2 326 749	7 371 321	8 934 818
Highest incidence cancers (all sexes, % total cancer incidence)					
Bladder	1·8	2·0	1·7	2·2	4·0
Brain, central nervous system	1·1	1·4	2·2	1·8	1·3
Breast	16·1	16·8	13·2	11·2	11·4
Cervical	13·8	12·6	7·9	3·3	1·1
Colorectal	5·7	5·8	5·6	11·0	10·6
Endometrial	1·3	1·2	1·4	2·0	2·5
Head and neck	3·9	4·2	14·2	3·8	3·3
Hodgkin lymphoma	0·9	1·0	0·7	0·3	0·4
Kaposi sarcoma	3·1	2·2	0·3	0·1	0·1
Kidney	1·6	1·8	1·3	1·7	3·0
Leukaemia	2·7	3·2	3·5	2·3	2·3
Liver	4·8	5·1	4·3	7·4	2·5
Lung	2·8	2·5	7·1	14·2	10·9
Melanoma	0·7	0·6	0·3	0·5	3·1
Non-Hodgkin lymphoma	4·5	4·6	2·9	2·4	3·0
Oesophageal	3·0	2·8	4·8	4·9	1·2
Ovary	2·2	2·4	2·8	1·6	1·3
Pancreas	1·3	1·3	1·1	2·5	3·1
Prostate	9·6	8·5	3·3	5·2	10·0
Stomach	2·9	3·4	5·2	8·0	4·0
Thyroid	1·2	1·6	1·8	4·4	2·4

(Table 2 continues on next page)

Work on this Commission report for SSA was initiated just before the COVID-19 pandemic began. During the pandemic, the commissioners worked together, within the limitations of COVID-19 restrictions, intending to provide comprehensive details and analysis on the state of the surging cancer burden in SSA, recommend key actions supported by data, and highlight case studies and successful models that can be adopted, adapted, or scaled accordingly across SSA to curb the increasing cancer crises. The report begins with a discussion of registries, data records, standardised reporting, and infrastructure. This discussion is followed by sections on cancer prevention, education, and awareness, and then coverage on screening, diagnosis, case findings, and treatment. Other sections cover palliative care, paediatrics, research, workforce training, and health systems including universal health care. The report concludes with a call to action. Methods used in sections of the report for analysis are adequately referenced, and where needed, further elaborated on in the appendix. The narrative sections of the report are informed by extensive reviews of the literature, analysis, and the knowledge and opinions of the commissioners.

Section 1: registries, data records, standardised reporting, and infrastructure

In 2012, all governments of countries who are members of WHO approved the Global Monitoring Framework on NCDs,[28] which includes a commitment to reduce premature NCD (including cancer-related) deaths by 25% by 2025 ("25 by 25"). The Global Monitoring Framework requires the collection of cancer incidence data, by type of cancer per 100 000 population—one of 25 indicators to monitor progress towards the 25 by 25 targets.[28] Furthermore, at the 70th World Health Assembly held in Geneva, Switzerland, in 2017, governments adopted an aligned cancer resolution (WHA70.12): cancer prevention and control in the context of an integrated approach, which supports the creation and maintenance of registries.[29] Unfortunately, as mentioned previously, there is low availability of PBCRs in Africa.[27] Increasing evidence, based in part on information provided by cancer registries, suggests that most new cancer cases now occur in Africa and other low-income and middle-income countries (LMICs), increasing from 15% of the global burden (in 1970) to 56% (in 2008), and anticipated to reach approximately 70% (by 2030).[30] Given these stark figures, there is an urgent need to improve existing registration infrastructure, to ensure that high-quality population-based cancer incidence data are consistent and available, while initiating sustainable cancer registration models where possible. Cancer registration requires investment in resources to generate high-quality data, yet the benefit gained through data-driven policies can be substantial and is needed to drive cancer control planning.[31] Furthermore, cancer registry information can have direct consequences on care, with a catalytic effect on improving patient outcomes over time. Accurate information provided by registries is more likely to allow for an effective public health policy and a more accurate calaculation of the long-term financial burden of cancer types. For example, the identification of variations in outcomes within a population allows benchmarking and assessment of comparative performance at multiple levels—including international, regional, and national—at the level of particular health systems, and hence improvement of targeted interventions. For example, registries have been used extensively and systematically for the planning of radiotherapy services in the UK.[32]

Given the importance of cancer registries, IARC launched the Global Initiative for Cancer Registry Development in 2011, as the first worldwide strategy to inform cancer control through improved data. In collaboration with the International Network for Cancer Treatment and Research, a virtual hub was established in 2012. By an agreement, the African Cancer Registry Network (AFCRN) acts as a consortium to provide hub activities in SSA. Beyond the apparent statement supporting the need for consistent financial support, the creation and operation of cancer registries within a SSA context has been quantified comprehensively in financial terms only recently.[33] The AFCRN has estimated approximately US$8–9 per cancer case, which compares favourably to the cost reported in Latin America[34] of approximately US$30 per case and across the EU[35] of approximately US$70 per case. However, these values have been derived via different methods and as such are only indicative. Additionally, they are only representative of the basal rate for fixed cost operations, ie, not including further in-kind contributions or additional variable costs, such as downstream research activities. Therefore, a substantial challenge persists in determining the true and representative operational costs of registries within an SSA context. Understanding within-country cost fluctuations and needs can be used as part of governmental long-term infrastructure investments and become eventually comparable regionally and internationally.

Linking information derived from cancer registries on the incidence of cancer in the population with data on the prevalence of risk factors allows for the estimation of the population-attributable fraction—ie, the proportion of cancer cases that might be prevented if a particular risk factor was eliminated (or reduced to a lower level).

	Sub-Saharan Africa	Low HDI regions	Medium HDI regions	High HDI regions	Very-high HDI regions
(Continued from previous page)					
Mortality by human development index (age-standardised rate worldwide per 100 000 people)					
All sexes	87·1	82·7	71·5	113·7	98·7
Males	83·6	78·0	76·7	141·1	122·9
Females	92·2	88·4	66·9	90·3	79·9
Deaths in 2020	520 348	439 852	1 513 219	4 524 833	3 478 767
Top highest mortality cancers (all sexes, % total cancer deaths)					
Bladder	1·5	1·7	1·4	1·7	3·1
Brain, central nervous system	1·5	1·8	2·8	2·5	2·5
Breast	12·4	13·3	9·7	5·5	6·6
Cervical	14·0	12·8	7·5	2·9	1·2
Colorectal	6·0	6·2	5·0	9·3	11·8
Head and neck	3·8	4·1	12·5	3·3	3·1
Kaposi sarcoma	2·5	1·9	0·3	<0·1	<0·1
Kidney	1·6	1·8	1·1	1·5	2·5
Leukaemia	3·1	3·6	4·0	2·7	3·3
Liver	7·0	7·2	6·3	11·6	5·1
Lung	3·9	3·4	9·9	20·3	20·5
Non-Hodgkin lymphoma	4·4	4·5	2·6	2·2	2·9
Oesophageal	4·4	4·0	6·9	7·5	2·5
Ovary	2·4	2·5	3·0	1·7	2·1
Pancreas	2·0	1·9	1·6	4·0	7·2
Prostate	7·7	7·2	2·4	2·9	5·0
Stomach	3·9	4·5	7·0	10·2	5·2

HDI=human development index.

Table 2: **Cancer incidence and mortality by HDI levels worldwide for all ages, 2020**[9,25]

	Gross domestic product per capita (current US$) in 2019	Disability-adjusted life-years in 2019 due to cancer	Annual economic loss due to cancer (US$)
Algeria	3974	675 351·37	2 683 822 080
Angola	2791	437 545·22	1 221 069 091
Benin	1219	171 621·13	209 280 413
Botswana	7961	62 882·26	500 626 120
Burkina Faso	787	343 883·48	270 600 408
Burundi	261	188 907·83	49 351 693
Cape Verde	3604	16 979·39	61 190 017
Cameroon	1507	453 127·92	683 067 776
Central African Republic	468	94 601·62	44 264 802
Chad	710	208 617·20	148 022 313
Comoros	1370	15 931·59	21 828 639
Congo (Brazzaville)	2280	105 770·32	241 153 065
Côte d’Ivoire	2276	376 763·46	857 639 202
Democratic Republic of the Congo	581	1 208 556·80	701 829 319
Djibouti	3415	25 421·09	86 811 112
Egypt	3019	1 818 126·39	5 489 297 794
Equatorial Guinea	8132	18 561·13	150 937 696
Eritrea	ND	131 667·07	ND

(Table 3 continues on next page)

	Gross domestic product per capita (current US$) in 2019	Disability-adjusted life-years in 2019 due to cancer	Annual economic loss due to cancer (US$)
(Continued from previous page)			
Eswatini	3895	30 153·20	117 437 059
Ethiopia	856	1 423 557·95	1 218 225 179
Gabon	7767	41 312·16	320 872 100
The Gambia	778	34 268·37	26 654 347
Ghana	2202	574 756·78	1 265 680 853
Guinea	963	263 870·29	254 064 846
Guinea-Bissau	697	32 812·12	22 879 725
Kenya	1817	742 113·02	1 348 083 118
Lesotho	1118	66 160·64	73 976 281
Liberia	622	63 944·21	39 766 454
Libya	7686	161 532·13	1 241 527 756
Madagascar	523	391 962·21	205 136 976
Malawi	412	369 334·08	152 000 305
Mali	879	302 825·46	266 186 005
Mauritania	1679	55 823·58	93 752 625
Mauritius	11 099	39 180·43	434 873 007
Morocco	3204	810 571·00	2 597 146 491
Mozambique	504	496 392·69	249 968 850
Namibia	4957	46 717·80	231 601 542
Niger	554	241 094·49	133 541 045
Nigeria	2230	2 526 342·71	5 633 387 262
Rwanda	820	236 562·22	193 986 992
São Tomé and Príncipe	1947	4 472·55	8 706 461
Senegal	1447	238 943·94	345 711 491
Sierra Leone	528	123 650·14	65 229 608
Somalia	320	307 111·93	98 287 540
South Africa	6001	1 467 214·84	8 805 344 786
South Sudan	ND	143 777·59	ND
Sudan	442	563 088·34	248 606 657
Tanzania	1122	1 076 035·85	1 207 443 296
Togo	679	121 649·41	82 635 258
Tunisia	3317	260 511·13	864 233 584
Uganda	794	742 524·84	589 817 982
Zambia	1305	346 869·74	452 686 951
Zimbabwe	1464	376 787·79	551 612 016

The economic loss due to loss of productivity and death due to cancer was calculated based on a method employed by the WHO Commission on Macroeconomics and Health, which valued one disability-adjusted life year at one year per-capita gross domestic product.[26] ND=no data.

Table 3: **Economic impact of cancer in Africa, 2019**

This impactful approach allows for the prioritisation of targeted public health measures and interventions. There are increasingly such high-impact examples from SSA for specific national contexts—eg, the fraction of cancers in Nigeria caused by alcohol[36] or obesity[37]—or for the continent-wide burden of cancer attributable to infectious agents.[38]

As part of this Commission report, a scoping review of the literature was done, to map out the gaps and limitations of cancer registration and data records in Africa. Studies and articles, that described these gaps in Africa, were identified from Google Scholar. The search was done on Aug 10, 2020, using the search terms “cancer” AND “sub-Saharan Africa” AND “challenges” AND “registry” AND “gap”, since inception of the database. 293 manuscripts were retrieved of which we used the eight that were directly and solely dedicated to cancer registries and the analyses of their challenges. We excluded manuscripts describing those registries that record HIV, and sometimes cancer as a comorbidity, or similarly those that record environmental (eg, heavy metal) exposure and sometimes cancer morbidity. The scoping review could have been more exhaustive, but we decided that there was thematic saturation with the manuscripts already identified (more details on appendix p 2). Of the eight relevant articles three were from west Africa, three from east Africa, one was from north Africa, and one from southern Africa.[9,39–45] These articles also provided suggestions on how these gaps can be improved over time in Africa. Here we provide a synthesised summary of the gaps and some recommendations on how they can be addressed, both now and in the future (panel 1), as well as how they might catalyse change.

Insufficient leadership and coordination systems for data records and cancer registration

The most pressing limitation, cited in all the articles from African countries, was inadequate leadership and coordination that is integrated within the health system structure of the countries.[9] This shortcoming leads to a fragile system for cancer registration in Africa, and insufficient coordination of data sources and stakeholders.[40,42,44] Management and coordination of the growing number of cancer registries in Africa is vital; and cancer registries across countries need to be continuously monitored and evaluated, with contextualised feedback gained via a well coordinated approach.[9,44] This necessity requires appropriate leadership, aligned within the health systems’ structures. Aligning the coordination of cancer registration efforts within government health systems might enhance local ownership and sustainability, to ensure strategic direction of cancer registries and enhance stakeholder involvement and confidence in the registry system.[9]

Although many countries have National Health Management Information systems that could potentially be linked to District Health Information systems, this situation is not necessarily the case, indicating that cancer-related data are not captured at the primary health-care level.[42,45] Although progress is being made, it tends to be in pockets of opportunity, rather than within a connected network, and, as such, further added-value cannot be achieved.[40,47,48] Common challenges mentioned are the low computer literacy of health-care professionals, high staff turnover, poor electricity supply and internet connectivity, high costs of procurement and maintenance of information systems, and the absence of an integrated approach for the implementation of health information systems. An increasing number of hospitals in SSA settings have information systems, but in most cases these systems are not tailored for immediate clinical needs[39] and are not necessarily oriented towards morbidity surveillance, capable of providing the diagnostic information required by cancer registries.[34]

Absence of harmonised standards for data records and cancer registration

An absence of standardisation in data records systems and inconsistencies in documentation practices among data sources and cancer registries is a major limitation of the cancer registration system in Africa.[45] There are no agreed upon or uniform variables to be collected among data sources within countries and across SSA. For example, there are often no unique patient identifiers or a uniform identification system for patients across data sources, to facilitate case linkages.[42,43,48] Linking cancer cases across hospital departments is one essential element to ensure quality and completeness in a registration system, and could be addressed by installing standardised documentation forms that would permit uniform data collection across data sources. Standardised documentation could also facilitate more consistent care in African settings, where primary care physicians treat many patients with cancer; typically, in capital cities and large urban centres since cancer treatment in SSA remains highly centralised. This standardisation will also permit the collection of comparable information, allowing multilevel and cross-national analysis of cancer care in SSA.[43]

Absence of a legal framework to support cancer registration

Another important gap is the absence of a cancer registration policy, act, or legislation that covers the establishment of cancer registries and other activities including funding, data access, and training and certification of cancer registrars in Africa. As a result, cancer is not a reportable disease in many African countries.[49] Even in countries where cancer is a reportable disease, compliance with reporting is low and there is no penalty for non-compliance.[41] This situation leads to numerous impediments in the execution of cancer registry activities.[44] For example, some private laboratories and hospitals do not allow access to cancer records by registry staff or do not submit cancer data to cancer registries, because such organisations do not have legislative mandates.[9,44] Similarly, some data sources ask to be paid before release of data, whereas others refuse to cooperate for unknown reasons. Additionally, many countries do not recognise cancer registrars as professionals and hence such positions do not exist in their public service structure. This situation might be linked to an absence of streamlined and contextualised training for cancer registrars integrated into the health education systems of many African countries.

Panel 1: **Summary of identified registry and infrastructure challenges in sub-Saharan Africa, and potential recommendations to address them**

Leadership and coordination systems[9]
- Strengthen dedicated leadership training
- Align registries coordination with national health systems
- Enhance stakeholder input, recognition, and feedback mechanisms

Absence of harmonised standards[45]
- Install harmonised documentation forms for uniform data collection across data sources
- Use large cancer treatment centres in capital cities as exemplars, setting the standards

Absence of legal framework[9,41,44]
- Create legal framework supporting cancer registration and registries
- Create legal framework supporting access and conditional use of registry data, including by third parties

Insufficient training of health-care staff[40–42,45,46]
- Maintain international collaboration opportunities for training of staff (eg, with the International Agency for Research on Cancer and WHO)
- Create and support local retraining opportunities

Poorly developed data infrastructure[41,42,44] (eg, inconsistent patient information, data records storage, and lack of available census and follow-up data)
- Introduce harmonised documentation practices
- Increase integration with existing systems; increase connectivity of existing systems
- Strengthen the systems recording census, follow-up, and vital statistics data

Insufficient funding[40,42,44,45]
- Introduce clear and transparent lines of budgetary support
- Advocate governmental and stakeholder long-term support and commitment

Research ethics and confidentiality[42]
- Set a transparent data governance policy
- Support legal permission to register all cancer cases over time
- Increase data safety and security

Absence of diagnostics facilities[40]
- Strategic prioritisation of achievable goals
- Leverage eHealth solutions for remote diagnostic capabilities

Insufficient training of cancer registry staff

Many countries do not have adequately trained personnel for cancer registration in Africa.[40–42,45,46] Many of the cancer registry staff are trained internationally and opportunities for re-training or continuous learning are scarce.[44] With limited support for cancer registries in institutions and countries, support for local and international training of staff is almost impossible.[41,44] Hence locally developed and delivered training programmes for cancer registry staff are needed in Africa. This provision would permit continuous training, re-training, and mentoring of registry staff to ensure that best registry practices are upheld. It would also enhance recognition of cancer registration professionals and integration of cancer registry staff into existing structures and systems.[44]

Poorly developed infrastructure and systems for data records and poor quality of data

There is a general absence of a well established culture for data collection and management practices that directly affects the quality of data in Africa.[41,42,44] This includes: (1) inconsistencies and inaccuracies in patient information; (2) poor storage of data records; and (3) a lack of census and vital statistics data.

First, poor documentation practices, which could be due to poor training of those doing the documentation, still cause many inconsistencies and inaccuracies in patient information across data sources.[43] Factors causing this issue are complex but might be culturally rooted. For example, age data in Africa are widely known to not always be reliable, due to several reasons including: (1) missing birth records and validation of patients' age; (2) lack of an individual's knowledge about their birth date and actual age, and rigorous efforts at medical registration to help the individual provide the best estimate keep changing across hospitals; (3) with increasing education, some patients actually know their age but tend to report older ages to use health insurance benefits available only to older patients; (4) concerns about patient confidentiality because cancer is still a stigmatising disease and most patients do not provide true identifiers, such as birth date; and (5) poor documentation practices among health workers, eg, using broad categories, such as adult instead of the age of the patient.[42,44] Other issues resonate with the general economic development of individual countries. For example, poor data quality control and assurance measures might be due to understaffing and work overload in health-care facilities. Similarly, incomplete contact address information of patients might be partly due to inadequate geographical information address systems in many African countries and definitions of usual and temporary residential addresses. Since cancer is a chronic disease, sometimes temporary addresses that are used to access hospital care can become usual addresses after 2–3 years of treatment, causing inconsistencies over time. Sometimes patients are unwilling to provide specific, detailed address information due to confidentiality issues and a lack of understanding of the needs for such information.[42] Establishing a uniform system and standard operating procedures, across health facilities, for probing, estimating, and verifying patient information such as age and residential address should be a priority for all health systems in Africa. This aim can be achieved by using existing systems such as mandatory use and requirement of national identification numbers, so that names and date of birth are written from official forms to decrease errors.[43]

Second, many health facilities do not have a well organised, easily accessible medical records system.[41,43] Although most cancer registries use some software, electronic medical records (EMRs) are not very common in Africa and cancer information systems are largely paper-based.[39,40,45,50] This absence of electronic information systems creates substantial challenges in maintaining good quality records. Furthermore, manually locating hard copy medical files in the records department of a large hospital is extremely challenging and labour-intensive, and can lead to incompleteness of data.[45] Widespread institutional EMR systems should be implemented in the future to improve the storage and easy retrieval of data records.[43] EMRs should be supported to collect information across disciplines and if this approach is coupled with the use of uniform unique patient identifiers, such as national identification numbers, it will help coordination and linkage of patients' information across data sources.[39,43]

Third, many African countries lack adequate follow-up systems and there is a scarcity of survival data due to inaccessibility to mortality and vital statistics data.[40,42,44] This problem can be addressed through improved linking of such datasets with cancer registries. However, if registries are not recognised by legal frameworks, their ability for linkage and access to public databases (eg, mortality data) becomes very difficult.

Insufficient funding for cancer registration activities

Funding for cancer registration activities remains inadequate for many African countries.[40,42,44,45] The cancer registration system in most African countries is not owned by government facilities and this situation has partly compromised the funding and sustainability of such services.[42] Cancer registration activities are sometimes supplemented from the personal resources of cancer registrars and advocates but this supplementation causes long intervals in data collection.[40,44] Long-term success and sustainability of cancer registration activities should be a shared responsibility between government, local, and international stakeholders. This success also requires clear and transparent lines of budgetary support and reporting channels.[42] Cancer registrars should also advocate for support from the government and other stakeholders by producing regular quality data and reports, making these available to the public and policy makers, so that such data can be used to apply for funding from relevant agencies.[42]

Registry research, ethics, and confidentiality

Although most cancer registries function under strict conditions of confidentiality and privacy of medical information, there are conflicting views about the use of registry data in research without previous patient consent. Some African countries have made informed consent a prerequisite for recording patients' information in the cancer registry database but for others this practice is still a grey area.[42] However, such requirements are widely recognised to potentially affect the completeness and validity of cancer registry data. Additionally, many settings might not be able to obtain patient consent and therefore all registries are recommended to get one-time unlimited approval to register all cancer cases over time.[42]

Scarcity of diagnostic facilities

An important gap for cancer registration in Africa is the inadequate diagnostic capacity for cancer. This shortage compromises the quality of cancer data and leads to an underestimation of the cancer burden. Cancer diagnostics need to be improved in SSA or strategies need to be devised to identify cases of cancer when not explicitly diagnosed in the available data.[40]

The previously mentioned challenges, although substantial, are not necessarily insurmountable. They require a systematic effort to be overcome, eg, through the integration with and use of existing infrastructures. One such example would be the further integration of National Health Management Information systems and District Health Information systems, or the integration of registries to EMRs, once the latter are being introduced into institutions. This integration would allow for an improved quality of collected data, quicker turnaround of clinical research, and improved use of staff time. The COVID-19 pandemic has highlighted the potential of new technologies in the provision of quality care. Thus, investigating the different ways in which health-related technologies can reduce the observed gaps between wealthy and less wealthy regions in SSA,[51] and connecting those with registries, would be interesting. This integration of health information systems might eventually become a considerable avenue in connecting cancer registries to delivery of care.

One of the major characteristics of SSA is the high fragmentation of services and structures. Cancer incidence is widely appreciated to be underestimated in settings with poor or absent registry data.[52] As such, the creation of partnerships and networks, such as the AFCRN, can facilitate the creation of high-quality registries, and support them through the exchange of information, experiences, and expertise. However, this work should be done in collaboration, with external organisations (eg, IARC and WHO) becoming members or partners in such networks. The link between networked structures will act as a multiplier in highlighting the need for cancer registries and their subsequent effect, while also providing further resilience to events of systemic pressure such as the COVID-19 pandemic.

The latest WHO report on cancer in SSA contains data from 25 PBCRs in the region (panel 2).[53] Meanwhile, a total of 30 registries in 23 countries, covering approximately 15% of the population of SSA, were included in the latest Union for International Cancer Control report.[54] Even though, according to WHO, 60% of the 46 countries in SSA had PBCRs in 2015,[55] only 18 could produce incidence rates that were a reasonably accurate reflection of the true cancer profile in that country.[54] Thus, more

Panel 2: List of the 24 sub-Saharan African countries with cancer registries, as of September, 2021 (information from The African Cancer Registry Network)

- Benin: Cotonou Cancer Registry
- Botswana: National Cancer Registry
- Congo (Brazzaville): Registre des cancers de Brazzaville
- Côte d’Ivoire: Registre des Cancers d’Abidjan
- Eswatini: National Cancer Registry
- Ethiopia: Addis Ababa City Cancer Registry
- The Gambia: Gambia Cancer Registry
- Ghana: Kumasi Cancer Registry
- Guinea: Registre de Cancer de Guinée
- Kenya: Eldoret Cancer Registry, Nairobi Cancer Registry
- Malawi: Malawi Cancer Registry
- Mali: Registre des cancers du Mali
- Mauritius: National Cancer Registry
- Mozambique: Maputo Cancer Registry and Registro de Cancro de Beira
- Namibia: Namibian Cancer Registry
- Niger: Registre des Cancers du Niger
- Nigeria: Abuja Cancer Registry, Calabar Cancer Registry, Ekiti Cancer Registry, and Ibadan Cancer Registry National System of Cancer Registries
- Rwanda: Rwanda Cancer Registry
- Seychelles: National Cancer Registry
- South Africa: Eastern Cape Province Cancer Registry and National Cancer Registry
- Tanzania: Dodoma Cancer Registry, Kilimanjaro Cancer Registry, and Mwanza Cancer Registry
- Uganda: Gulu Cancer Registry and Kampala Cancer Registry
- Zambia: National Cancer Registry
- Zimbabwe: National Cancer Registry (Harare and Bulawayo)

Panel 3: Training cancer registry staff in Kenya

The International Cancer Institute, working in Kenya and several countries in sub-Saharan Africa, has been participating in the training of cancer registry staff across the continent by upskilling them to correctly identify datapoints, such as gender, the International Classification of Diseases 10th revision code, topography, and morphology, according to the CanReg 5 software requirements. CanReg 5 is an open source tool to input, store, check, and analyse cancer registry data, provided by the International Association of Cancer Registries. It facilitates the production of comparable analyses across registry populations. The International Cancer Institute co-hosted the training of cancer registry staff from seven African countries at its centre in Eldoret, Kenya, in early 2019, with faculty drawn from WHO and IARC. Both 2-week basic and 3-week advanced cancer registry courses were held. For the advanced course, 35 participants from Kenyan counties’ cancer registries and African countries (including Uganda, Tanzania, Rwanda, Burundi, Swaziland, and Malawi) attended.

Due to COVID-19 and subsequent restrictions on travel, and to maintain the momentum, the International Cancer Institute partnered with the African Cancer Network and ran a 10-week, online cancer registration course (April–June, 2021) with more than 60 participants from across sub-Saharan Africa attending the webinar sessions, once every 2 weeks, who were also invited to virtual multidisciplinary tumour boards, also held once every 2 weeks, which are part of routine operational processes. This inclusion ensures appreciation of the multidisciplinary nature of cancer care and control, as well as a broad perspective on data generation and collection.

Panel 4: The South Africa Cancer Registry: an example with a legal framework to support cancer registration

South Africa's first pathology-based National Cancer Registry was established in 1986, by the South African Institute of Medical Research (now the National Health Laboratory Service) together with the Department of Health and the Cancer Association of South Africa. In 1990, standardised methods and routine reporting methods were implemented.[58,59] Between 2002 and 2009, South Africa was burdened by a high incidence of infectious diseases (ie, HIV and tuberculosis) creating a competing health system, where non-communicable diseases, including cancer, were not prioritised.[60] The subsequent lack of both capital and human resource support halted the progress and development of the National Cancer Registry in South Africa, resulting in a 10-year backlog on the reporting and publishing of cancer incidence data.[59,61,62]

Finally, in 2011, the National Cancer Registry was formally established by the South African Department of Health as the delegated agency for the collection of cancer surveillance data. This important development was made possible by the South African Department of Health Enacted Regulation Number 380 of the National Health Act (Act 61 of 2003).[63] This regulation established cancer as a reportable disease, with every health-care worker obliged to report confirmed cancer cases to the National Cancer Registry and mandated the registry to establish population-based cancer registries for South Africa. Since 2017, the first urban cancer population-based registry, the Ekurhuleni Population-Based Cancer Registry, was established in the Gauteng province. This registry follows gold-standard criteria for cancer registration globally, ie, recording cancer cases as diagnosed clinically, radiologically, and pathologically.[64]

The current South African National Cancer Registry is a pathology-based cancer registry, which is a division of the National Health Laboratory Service. The National Cancer Registry serves as South Africa's primary source of national cancer incidence data. The National Cancer Registry objectives are (1) to collect, analyse, and report cancer statistics in South Africa, (2) to guide and support the Department of Health on cancer initiatives and other cancer programmes from non-governmental organisations, non-profit organisations, and any other parties interested in cancer prevention, control, and care in South Africa, and (3) to inform cancer policy and guidelines in South Africa.[65] Therefore, the registry is integral to the development of cancer prevention and control policy for South Africa. Additionally, it also has an important role in maintaining and developing both national and international awareness of the underlying cancer burden in South Africa.[59]

work remains to be done both in terms of establishing PBCRs in SSA and to maintain the high level of data quality required.

Therefore, tackling the challenges mentioned previously, aligning leadership, available infrastructure, and workforce training are crucial to the success of implementing cancer registries.[56,57] There is currently a paucity of case studies for SSA cancer registries, to develop a comprehensive understanding of needs and potential solutions. The further creation and implementation of cancer registries would almost certainly require available human and financial capital, and sufficient training capacity (panels 3, 4). Registries can be positioned as a valuable health-care tool, engaging clinical staff in the shared task of improving the quality of care and as a reference point for the dissemination and sharing of accrued knowledge and best practices. Tailoring the integration of registries to the local health-care context could lead to research outcomes that are practically feasible to implement and can directly improve patient treatments.

Section 2: prevention, education, and awareness of cancer

Cancer prevention

Cancer prevention is crucial for SSA given that prevention can be less expensive and is always better than cure. Advances in preventive measures such as tobacco control and screening for female breast cancer, cervical cancers, and colorectal cancer have substantially reduced cancer mortality rates in high-income countries. However, SSA countries have benefited little from these advances. Most SSA countries rely on a reactive versus proactive response to cancer. Cancer prevention services are offered; however, these are primarily opportunistic rather than population-based.[66] Because of the scarcity of organised programmes, ineffective population outreach, fragmented service delivery, unavailable infrastructure, and limited financial resources, most SSA countries report prevention programme participation rates below 50%, and, in some cases, as low as 10% or less.[66] Previous preventive approaches in SSA were unsuccessful for many reasons, including a lack of basic and translational research to understand cancer causes and biology in the Indigenous African population and its prevention and treatment, inadequate surveillance, and insufficient government commitment. At present, two-thirds of African countries have established NCCPs, compared with 46% in 2013, that include prevention strategies.

The key to primary cancer prevention is identifying cancer causes and reducing the population's exposure to those causes. Most of the research into cancer causes has been done in high-resource settings. However, based on scant data, Africa's leading causes of cancer are infectious diseases, tobacco use, energy imbalance, and alcohol consumption.[67] Infectious agents account for a substantial portion of the cancer burden in SSA, of which viral agents contribute the most to the disease, including human papillomavirus (HPV), Epstein-Barr virus, Kaposi sarcoma-associated herpesvirus, and hepatitis viruses B and C. These viruses are the causative agent of cervical cancer, Burkitt lymphoma, Kaposi sarcoma, and hepatocellular carcinoma, respectively (appendix p 5).[68] The mortality and morbidity resulting from these diseases are high due to poverty, ignorance of disease processes, poor access to health-care facilities, and an absence of effective prevention programmes.

Human papillomavirus

More than a third of all cervical cancer deaths globally occur in SSA, even though the population represents only 14% of the world's female population. WHO recommends vaccination, early detection, accurate diagnosis, and

	Cytology using Pap smear test	Early screening and detection	Human papillomavirus DNA tests	Single-visit see-and-treat approach	Visual inspection with acetic acid combined with cryotherapy	Visual inspection with acetic acid	Visual inspection with Lugol's iodine
Burundi	No	No	No	No	No	No	No
Comoros	No	No	No	No	No	No	No
Democratic Republic of the Congo	No	No	Yes	No	No	Yes	Yes
Eritrea	No	No	No	No	No	No	No
Ethiopia	No	Yes	Yes	No	Yes	Yes	Yes
Kenya	No	Yes	Yes	Yes	Yes	Yes	Yes
Madagascar	Yes	Yes	Yes	No	Yes	Yes	Yes
Rwanda	No	No	No	No	No	Yes	No
Tanzania	No	Yes	Yes	Yes	Yes	Yes	Yes
Uganda	No	Yes	Yes	Yes	No	Yes	Yes

Kenya, Ethiopia, Madagascar, Tanzania, and Uganda have the most screening modalities in legal instruments, as compared with the rest of the countries.

Table 4: **Different screening modalities for cervical cancer among east African countries (adapted from Njuguna and colleagues)[69]**

access to appropriate therapy to manage the disease. The recommended screening modalities for cervical cancer include HPV testing, cytology (pap smear), and visual inspection with acetic acid, as well as single-visit see-and-treat management (table 4). Implementation of a cervical cancer screening programme using a pap smear has substantially decreased cervical cancer death in high-income countries. However, the establishment of such a programme requires infrastructure and trained personnel that are not readily available in many SSA countries.[70] Visual inspection with acetic acid compared with cytology screening is advantageous because non-physician providers can perform the test with similar sensitivity at a lower cost than the pap smear. However, the process is less specific than the pap smear and can lead to overdiagnosis and overtreatment.[71]

Understanding the role of HPV in cervical cancer and developing HPV test kits and vaccines have created many cervical cancer prevention opportunities. Several vaccines are currently available; these can reduce the incidence and death rate of cervical, anal, vulvar, and penile cancer, as well as cancer of the tonsil and nasopharynx. However, existing vaccines against HPV might not protect against many of the subtypes of HPV in Africa, or reach much of the population at high-risk, since compliance tends to be low in these low-resource countries (appendix p 6). A driving factor behind low HPV vaccination compliance is inadequate resources to finance and deploy the vaccines in the region.

As of 2019, 16 countries in SSA had rolled out HPV vaccination programmes, with an average vaccination coverage rate of 49·4% (range from 1% to 96%).[72] Among these countries, Rwanda has had a successful experience with implementation and is the first low-income country to implement a national HPV vaccination programme. The government committed resources and devised a comprehensive plan for cervical cancer prevention, screening, and treatment that included a national HPV vaccination campaign, expanded cervical HPV infection screening and treatment, and pathology education.[73] This commitment has made Rwanda one of the countries with the highest HPV vaccination coverage worldwide because of its school-based vaccination programme and strong government support, especially from first lady Jeannette Kagame, who publicly fostered, in 2009, a negotiation between the drug company Merck, the Rwandan Ministry of Health, WHO, and several charities.[74]

Another first lady, now former, Christine Kaseba of Zambia, became an advocate for visual inspection of the cervix with acetic acid, enabling early detection of precancerous lesions and immediate treatment. Her efforts and several other African first ladies' efforts have led to cervical screening programmes in Zambia, Rwanda, Mozambique, Namibia, Zimbabwe, and Sudan. Today, health-care personnel (eg, midwives) use smartphones to send pictures of suspicious lesions to physicians and supervisors, with the photographs of lesions also allowing for quality control and assessment. Meanwhile, Gavi, the Vaccine Alliance supports some SSA countries to help them access HPV vaccines. Senegal was the first Gavi-supported country in west Africa to introduce the HPV vaccine into its routine immunisation programme. Senegal has immunised more than 1·5 million girls against HPV in the past 3 years.[75]

In addition to the limitations in health systems and government support, sociocultural factors play a role in women's health-seeking behaviour. These factors include the belief that cervical cancer is due to supernatural causes, a tradition that allows a man to have more than one wife and partner, and inadequate or absent sex education. Many published studies in the region have indicated a low level of public education on cervical cancer, prevention, and control. For example, a cross-sectional study[75] of 285 adolescents in Ghana indicates that about 91·2% and 95·4% of the study participants had not heard of HPV or the HPV vaccine, respectively.

Moreover, a systematic review that assessed SSA adolescents', parents', and health-care professionals' knowledge, awareness, and acceptability of the HPV vaccine indicated an urgent need for more education to inform the public about HPV, the HPV vaccine, and cervical cancer.[76]

Hepatitis viruses

No robust epidemiological data on liver cancers in SSA are available. However, according to data collected from African cancer registries in 2018,[38] the proportion of liver cancers diagnosed histopathologically as hepatocellular carcinoma in SSA was 77%, varying by region from 67% to 88%. Of these, 50% of cases were attributable to hepatitis B virus and 17% to hepatitis C virus. Therefore, the number of hepatocellular carcinomas due to hepatitis B and hepatitis C virus was about 18 300 and 6400 cases, respectively.[38]

In 2016, all members of WHO endorsed the goal to eliminate viral hepatitis by 2030 by implementing the use of a hepatitis B virus vaccine, including providing birth doses and other measures such as full coverage of the hepatitis B virus vaccination schedule, providing access to affordable diagnostic assays and treatment, and addressing the social stigmas associated with the diagnosis of the disease.[77] As a result, worldwide, the proportion of children younger than 5 years of age infected with hepatitis B dropped to less than 1% in 2019, whereas in SSA this proportion remained high at 2·53%, also in 2019,[78] in the same age group. Although many countries in SSA have the hepatitis birth-dose vaccine as part of the infant immunisation schedule, such as Nigeria, several, such as Tanzania, do not. Coverage of the hepatitis B virus birth-dose vaccine is only 10% in SSA, and only 11 of 54 countries in SSA have a policy of birth-dose vaccination, while other countries are developing one. Nigeria is among 13 other countries on the continent advancing the implementation of a hepatitis B birth-dose vaccine in alignment with a WHO regional resolution in 2004. In 2015, Nigeria championed developing a Viral Hepatitis National Strategy with the ambitious goal of eliminating viral hepatitis infections by 2030, and the nation has been making great strides in routine immunisation and treatment.[79]

WHO has recommended universal hepatitis B birth-dose vaccination for all infants within 24 h of birth, which serves as a key performance indicator of national immunisation programmes. However, the hepatitis B vaccine birth dose is not part of the vaccines supported by Gavi because of the implementation challenges in administering the vaccine at birth and its low cost per dose. Another reason for the low coverage in SSA is the high number of out-of-facility births. Therefore, administering the vaccine outside the recommended 24-h timeframe requires cold chain storage and skilled birth attendants. However, around 50% of birth deliveries are handled by unskilled birth attendants, especially in rural or hard-to-reach areas in SSA. Therefore, SSA countries need to address these issues by using alternative approaches such as developing temperature-stable vaccines and integrating vaccine delivery into national programmes.[80]

The initiation of hepatitis B virus vaccination at birth versus 6 weeks has been controversial in some national programmes in SSA. For example, in Tanzania (where birth-dose hepatitis B vaccination is not available) children are vaccinated with hepatitis B vaccine during the 4th, 8th, and 12th weeks after delivery, based on the understanding that most hepatitis B virus transmission occurs within the first 5 years of life. However, a low protective rate has been reported in Tanzanian children, where 70% of vaccinated children who are younger than 5 years of age are unable to mount a protective level of immunity.[81,82] The low level of immunity is attributable to the delayed effect of the first dose of the vaccine, given at the 4th week, when an infection is probably likely to have already occurred.[81] However, studies in Uganda have shown the efficacy of vaccine series initiation at 6 weeks.[83]

In addition to vaccination, the key to addressing the high burden of hepatitis B infection in people in SSA is to improve awareness and access to hepatitis B information, screening, and follow-up care. There are many opportunities to intercept the hepatitis B virus infection along its disease progression continuum to prevent such progression. Tests for antigens, viral load, antibody levels, and liver transaminases in an individual's blood during these presentation stages are available and can distinguish between each stage (appendix p 7).

Helicobacter pylori

H pylori, a bacterial infection acquired during childhood, is the most common cause of stomach cancer. The risk factors for acquiring the bacterium are infected parents, infected siblings, overcrowding, and unsafe water. The bacterium infects about 50% of the world's population, and its prevalence reaches 80% in Africa and varies in prevalence levels between countries, with South Africa ranging from 51% to 78%, Nigeria from 83% to 92%, Benin from 70% to 81%, and Democratic Republic of the Congo from 70% to 81%. Due to scant epidemiological data, the association of *H pylori* with stomach cancer in the SSA region is not entirely well known, and disparity exists between the occurrence of the infection, and the expression of clinically significant disease.[84]

Tobacco

The use of tobacco is the leading cause of cancer worldwide. Tobacco is a risk factor for many cancers, including lung, head and neck, oesophageal, and bladder cancer. Unlike high-income countries, tobacco use is increasing in Africa due to intensified marketing by tobacco companies, a socioeconomic transition, and no comprehensive tobacco control programmes in most parts of the region. Tobacco use varies within these countries, with most in the early stages of the Tobacco Epidemic Model, suggesting that research in the region is crucially needed to inform preventive and control initiatives.[85–87] According to Statista 2019, about 26·7% of Lesotho's, 20·3% of South Africa's, and 15·8% of Zimbabwe's population consumed tobacco in 2019 (figure 2A).[88] Smoking prevalence prediction indicates a smoking increase of 41%, from 12·8% in 2010, to 18·1% in 2025, across the continent.[90]

The WHO Framework Convention on Tobacco Control, adopted by the World Health Assembly in May, 2003, requires state parties to adopt and implement tobacco control measures, as well as guides governments about suggested policies and programmes for reducing tobacco use. The crucial component of the Framework Convention on Tobacco Control includes banning advertising, prohibition of smoking in public places and workplaces, imposition of high taxes, and media campaigns.[91] 44 SSA countries signed up to the Framework Convention on Tobacco Control and passed the tobacco control legislation; however, enforcing the law has been variable in the region, with implementation rates ranging from 9% in Sierra Leone to 78% in Kenya, with Uganda and South Africa accomplishing the highest implementation rates. Lack of political will, rather than inadequate financial resources, has been identified as a reason for the low implementation of the Framework Convention on Tobacco Control in Africa.[92]

Energy imbalance

Energy imbalance is caused by consuming too many calories and a lack of exercise (or burning too few calories), which leads to obesity and energy storage. It is associated with at least 12 types of cancers, including endometrial, gastric, oesophageal, liver, kidney, pancreatic, colorectal, gallbladder, and breast cancers. At least 18% of all cancers and about 16% of cancer deaths in the USA are related to excess bodyweight, physical inactivity, alcohol consumption, or poor nutrition.[93] Energy imbalance is a growing cause of cancer in Africa due to urbanisation and adoption of high-income country habits, such as increased consumption of calorie-dense processed foods and sedentary lifestyles. Many African people have abandoned a more active rural lifestyle and moved to live in large, crowded cities, where travelling in cars is more common and where people spend much time viewing television. As a result, the prevalence of adult obesity has increased by 1400% in Burkina Faso and by more than 500% in Ghana, Benin, Ethiopia, and Togo during the past 30 years. According to a recent study by the Institute for Health Metrics and Evaluation at the University of Washington, WA, USA, eight African countries are among the 20 nations worldwide with the most rapidly rising rates of adult obesity (figure 2B).

Indeed, there are sociocultural influences on attitudes towards obesity, physical activity, and dietary changes. In many SSA countries, an increase in body fat is associated with beauty, health, and prestige, whereas being thin is associated with poverty and disease.[94] Moreover, African mothers generally nurse their babies, which contributes positively to both the child's and mother's health. However, new mothers in some populations are being encouraged, through company marketing, to use a bottled formula to feed their babies instead of breastfeeding. There is increasing evidence that breastfeeding reduces breast cancer risk.[95]

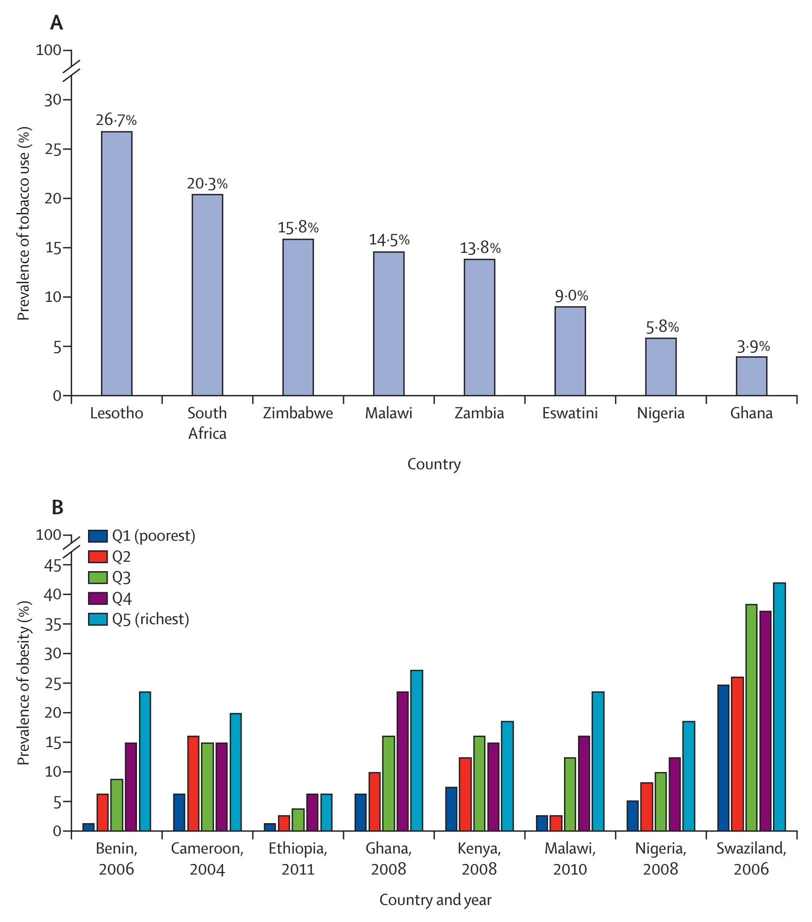


Figure 2: **Prevalence of tobacco use and obesity**

(A) Prevalence of tobacco use in 2019 in selected African countries (adapted from Statista[88]). (B) Prevalence of obesity by wealth quintiles in selected African countries (adapted from Agyemang and colleagues[89]). The year represents the period the study was done.

In SSA, there is a scarcity of literature on the risk factors for childhood obesity. Danquah and colleagues[96] did a systematic review to examine the research efforts that promote a healthy lifestyle in Africa. The study identified only 68 articles describing the risk factors for childhood obesity and morbidity in SSA. Of the 68 articles found, 53 reported risk factors, 12 reported morbidities, and three reported both risk factors and morbidities. This paucity of published literature suggests that knowledge about the underlying factors for children's and adolescents' unhealthy diet and physical inactivity in SSA is scarce. For example, in Kenya, although adolescents have access to nutritious foods, such as fruits, vegetables, and animal protein, they tend to primarily consume unbalanced diets with a high intake of carbohydrates, oily foods, and sugar-dense processed foods and drinks.[97] The primary physical activity types in this demographic are sports and domestic chores, while long periods of time spent sitting and chatting, and watching sports games and movies, are typical.[97] Health behaviours that reduce cancer risk include consuming a diet high in fruits and vegetables and low in red meats and processed foods and incorporating efforts beyond the individual, such as community level interventions, promoting the availability of affordable healthy food and beverages, or encouraging breastfeeding, to reverse or prevent obesity. WHO has established recommendations on preventing obesity that are highly relevant for SSA.[98]

Alcohol

Alcohol is a carcinogenic substance and is a cause of mouth, pharynx, larynx, oesophagus, liver, colorectal, and female breast cancers. Almost all cultures underappreciate the danger of alcohol consumption. In 2010 alone, alcohol-attributable malignancies resulted in 337 400 deaths worldwide, most of which were in men, with liver cancer accounting for a substantial proportion (23·9%) of these deaths.[99] In the WHO African region, 4·8% of cancer cases were attributable to alcohol consumption in 2012.[100] In SSA, alcohol consumption varies between countries: some countries have high alcohol abstention, while others have high alcohol consumption, associated with negative health and social consequences. African women drink less than African men. In a survey of nearly 34 000 African women, 81% reported lifetime abstinence. People who drink alcohol ranged from 1% in Malawi to 30% in Burkina Faso. Among current drinkers, heavy drinking varied between 4% of women in Ghana and 41% in Chad, and risky single-occasion drinking ranged from less than 1% in Mauritius to 58% in Chad.[101] Awareness campaigns in these countries with high volume alcohol consumption are urgently needed.

Although there is no known safe level of alcohol consumption, most experts recommend no use or limited use of alcohol. Kenya and Rwanda took an active role in advocating for less alcohol consumption and proposed a draft resolution that would lead to adopting the global strategy to reduce harmful alcohol use at the World Health Assembly in 2008.[102] At the same time, African ministers of health adopted the regional strategy to reduce alcohol's harmful use in the African region. Furthermore, African countries declared commitments to reduce diseases and harm caused by alcohol use at the UN General Assembly in 2011, endorsed in the WHO Global Action Plan for the Prevention and Control of NCDs in 2013.[103] They set a target of at least a 10% relative reduction in harmful use of alcohol. In 2016, at the World Health Assembly, African countries requested to set up a focus group to look at harmful alcohol use as a risk factor for NCDs.[103]

A recent study[103] found substantial room for policy improvement across the majority of the African continent. Moreover, no countries in SSA have implemented the WHO Framework for Implementing the Regional Strategy to Reduce the Harmful Use of Alcohol (2014–20), which establishes essential indicators to monitor the regional strategy's implementation to reduce harmful consumption.[104,105] Therefore, changes in specific policies are needed to reduce the harmful use of alcohol in these countries. These changes need solid political commitment and adjustment of policy responses.

Environmental factors

The few available data suggest correlations between environmental exposures common to SSA and increased incidence of specific cancer types.[19,20] For example, associations have been found between pesticide exposure and increased risks of developing various cancers, including bladder cancer, breast cancer, colorectal cancer, non-Hodgkin lymphoma, and hepatocellular carcinoma.[106] Meanwhile, the effects of industrial metals contaminating the environment in Africa, such as arsenic or cadmium, on health are comparable to those observed elsewhere, including agents that cause cancer.[19,20] Beyond agricultural and industrial activities, poor urban planning has led to the generation of and exposure to more hazardous waste due to poor disposal systems. In considering interventions, some avenues for interventions to reduce both exposure and health risks include comprehensive training and use of protective safety gear and clothing and safe handling practices for workers. Additionally, biomonitoring of effects in workers might be a useful way to assess individual risks. Environmental contamination from products of mining including heavy metals needs increased regulatory oversight, to curb the exposure risks. Improved hazardous waste disposal systems need to be developed and better regulated to reduce risks for populations. However, more analysis is needed on the association between these exposures and cancer epidemiology in SSA. For example, more research is needed with improved pesticide exposure assessment methods, and potentially incorporating multiple approaches and longitudinal studies to incorporate seasonal effects.[106] Overall, there is a need for more action and policy to minimise the exposure of SSA populations to environmental factors causing cancer and other diseases.

Cancer awareness and promoting the adoption of healthy habits

Population knowledge and awareness about cancer risk factors are essential and the basis for constructing a cancer control programme. Public health campaigns to raise awareness about avoiding harmful risk factors or adopting healthy habits are efficient and cost-effective approaches to reducing mortality and morbidity from cancers associated with these risk factors. The European

Code Against Cancer has published 12 ways (appendix p 8) to reduce cancer risk. The European Code Against Cancer is an initiative of the European Commission, developed by IARC. The European Code Against Cancer aims to inform people about actions to reduce cancer risk for themselves or their families. Adopting these behaviours in SSA would help to substantially reduce the risk of cancer and thwart the current rise.

There are successful stories of cancer awareness in some SSA countries. Studies[2,107,108] have shown that civil societies could work with governments to create cancer awareness education programmes, scalable across SSA in parallel with other initiatives. One study in Tanzania has shown that such programmes can also help to downstage cancer in SSA, where most patients present with late-stage cancers.[109] Other countries such as Rwanda have nationalised their cancer prevention awareness campaigns, including during monthly car-free days (occurring during the 2nd and 4th week of every month).[74] Such examples (panels 5, 6) can serve as models to be adopted or adapted by other SSA countries.

Section 3: screening, diagnosis, and treatment

An estimated 30–50% of all cancer deaths in low-income and middle-income countries (LMICs) could be prevented if population screening and early diagnosis were addressed to ensure patients with curable cancers are treated early enough. The example of screening in Sudan (panel 6) highlights the importance of early detection programmes. However, early detection programmes might be frustrating for both patients and health authorities if patients are unable to afford accessible treatment.[110] Therefore, efforts to increase screening should accompany those to increase access to treatment. SSA has the lowest availability of facilities for cancer diagnosis and treatment of any region worldwide and little evidence is produced in SSA to guide best practice.[66] A 2020 assessment of 34 SSA health-care centres offering cancer treatment services revealed that, while 33 perform basic histology on suspected cancer samples, only 24 (70·6%) perform immunohistochemistry and 18 (52·9%) perform flow cytometry.[111] Nearly all sites (32) are equipped to perform CT scans, ultrasounds (34), and x-rays (34), whereas only 23 (67·6%) can offer MRI scans and just four (11·8%) are capable of performing PET scans. Most sites administer chemotherapy (29) and offer surgical oncology services (31), whereas approximately half (18) provide radiotherapy services.

Early diagnosis and effective treatment in SSA are also invariably tied to a patient's ability to pay. Patients frequently have to pay out of pocket for their health-care costs, resulting in many cases of catastrophic expenditure. High costs and poverty are major challenges in access to treatment across all settings in Africa. On the supply side, for example, African countries pay higher prices for cancer drugs compared with a region in Latin America with a similar income level, despite comparable GDP or disease burden.[112] In this context, much still remains to be done to improve cancer screening, diagnosis, and treatment in SSA.

Panel 5: Breast cancer awareness in Ghana

A successful model of a cancer prevention awareness programme in Ghana is that of Breast Care International (BCI). BCI is dedicated to creating breast cancer awareness among Ghanaian women and men (with a special focus on rural areas), educating them about the realities of breast cancer, undertaking clinical screening procedures leading to further diagnosis, counselling, treatment, and rehabilitation, as well as research into the various breast cancer pathologies. Breast cancer is a leading cause of cancer death in Africa, and a major concern in sub-Saharan Africa is the late presentation of the disease. In Ghana 60% of cases are detected at late stages.[108] Studies have highlighted the positive impact of BCI's work, including during COVID-19 restrictions.[2,108]

The BCI programme is based on providing free screening procedures through clinical breast examination and education on breast cancer wherein participants are trained how to perform breast self-examination and informed of the symptoms of the disease, its implications for health, and the benefits of early detection in improving the chance of survival. BCI's members travel approximately 3 weekends per month to ten regions of the country to conduct outreach programmes in the local languages in communities. BCI also organises urban programmes and frequent talks in the media, especially on the radio and television. Since its inception, BCI has screened more than 400 000 women for breast cancer in Ghana. In outreach programmes, lectures are given by experts to create awareness and educate communities, during which pictures and other materials are shown and breast cancer survivors participate to share their stories and provide peer education. After the awareness events, the participants are invited to ask questions. The importance of contracting the National Health Insurance Scheme and its utility for partially covering mammography and breast cancer treatment expenditures are discussed during the lecture. BCI also partners with other organisations like Susan G Komen for the Cure in organising events. These national events have drawn tens of thousands of people (politicians and non-politicians, presidents and former presidents, first ladies and second ladies, and the young and the old) in breast cancer awareness walks.

Work evaluating the impact of BCI's breast cancer awareness programmes in Ghana has shown they are having a substantial impact in improving knowledge, attitudes, and practices towards breast cancer in Ghana.[108] During the COVID-19 pandemic, cancer prevention activities, including awareness, early detection screening, or vaccination were curtailed. With many women now at home, BCI started using information and communication technology forms of awareness education including social media, Zoom, radio stations, and other electronic media to teach women and encourage routine breast self-examinations as part of breast cancer screening. This approach is now being integrated with face-to-face approaches in raising cancer awareness. BCI has also been using its platform to educate people about other cancers like cervical and prostate cancer, and other non-communicable diseases like hypertension, stroke, diabetes, and sickle cell disease. Overall, BCI programmes have had a positive impact in Ghana and the organisation has been commended by the government. This success highlights a model where civil society can work in collaboration with governments in improving cancer awareness and education in an approach that can be scaled-up across sub-Saharan Africa in parallel with other initiatives in other countries. In 2021, one of BCI's projects (HOPE, helping others through personal experiences), with breast cancer survivors, was adopted by the ABC's for Global Health Initiative as a toolkit to be used by other low-income and middle-income countries.

Population screening and early diagnosis

One of the key domains to ensure effective treatment is the provision of accurate and timely screening and early

Panel 6: Breast cancer awareness and screening in Sudan

A study in Sudan[107] examined whether a peer breast cancer awareness and early examination programme would help women overcome their fears about cancer detection, diagnosis, and treatment (appendix p 16). The study provided evidence of the feasibility of an intervention that relies on trained volunteers from the community to provide cancer awareness and early cancer screening programmes. Women in the study area had little knowledge about recognising cancer or seeking appropriate treatment and might not have the resources to cover transportation or accommodation at urban health centres. The young women volunteers provided cancer awareness and screening from a familiar and trusted person within the village, which obviated the need to seek screening outside the village. Studies[2,107,108] that have used local volunteers for cancer education have shown that they are usually more effective than professionals in disseminating information because women identify more easily with their peers who share the same environment, community, and beliefs. During the 2-year study period from 2010 to 2012, 70% (10 300 of 14 788 women in 29 villages) of women in the intervention villages were screened, of whom 138 were identified as having breast abnormalities and were referred to the district hospital for diagnosis and management. 20 of these women did not report to the hospital. Of the 118 women who reported, 101 were diagnosed with benign lesions, eight with carcinoma in situ, and nine had malignant disease. After treatment, 12 of the 17 women with either carcinoma in situ or malignant disease (four had early breast cancer and eight had ductal carcinoma in situ) were disease-free and had good prognosis. Only four women reported to the centre in the control villages: one was found to have a benign lesion, whereas three were diagnosed with advanced disease. The eight women with carcinoma in situ are still alive and are being followed up annually or more often, depending on their disease status. Two of the women died after 2 years. At the end of the 10 years, the study findings show that a screening programme using local volunteers can increase the detection of breast cancer in asymptomatic women in low-income rural communities. These findings can inform policy makers to design breast cancer control programmes in Sudan and other similar countries in sub-Saharan Africa.

diagnosis. Diagnostics, which include pathology and laboratory medicine and imaging, are a crucial component of cancer care. In most countries in SSA, efficient histopathology specimen referral systems are absent or inadequate due to poor infrastructure. Unregulated laboratory practices result in patients being misdiagnosed with downstream consequences—ie, they have a more advanced disease stage when they are finally diagnosed correctly. The lack of reliable pathology data linked to cancer registries, as well as an overall failure to collect basic epidemiological data, means that accurate assessments of the need for and quality of pathology and laboratory medicine and imaging services on a country-by-country basis are not available. In SSA, access to diagnostics is unequal, with most major cancer diagnostic facilities located in urban areas. For example, in Malawi, only 20% of the population is within 10 km of a health-care facility. Screening and diagnostic services are also hampered by long periods of equipment downtime due to inadequate maintenance (often because of the high costs) or scarcity of reagents.

Pre-analytical and analytical handling of specimens can also affect the final quality of pathology specimens. There is a need to homogenise specimen handling, analysis, and reporting in all SSA settings. Development of regional or centralised laboratories, creation and implementation of guidelines, and training of health workers are all needed to build sustainable cancer diagnosis pathways into cancer systems. There is a need to develop both national and regional standards for specimen handling and referral, including regional quality assurance or control laboratories. Many potential patients with cancer have to wait for an initial histology then pay extra for further immunohistochemistry, resulting in major treatment delays, and, in many cases, stage shifts from curable to incurable disease. There is a clear need to address pricing and to incorporate comprehensive tests such as immunohistochemistry, which group the costs of services provided together.

The 2019 *Lancet* Commission[113] on diagnostics highlighted the key challenges of pathology and laboratory medicine and imaging services in LMICs and provided practical solutions to governments, non-governmental organisations, and ministries of health. The Commission noted that developing sustainable, affordable, and timely pathology and laboratory medicine and imaging services is a multi-layered challenge, which requires a combination of established and more innovative approaches. Advocacy for pathology and laboratory medicine and imaging services should be integral components of the cancer care pathway planning and try, wherever possible, to leverage existing infrastructure of successful programmes eg, the US President's Emergency Plan for AIDS Relief, which supports an integrated response to HIV and tuberculosis. The development of population screening as a contributor to early diagnosis remains underdeveloped across most of SSA, with the exception of cervical cancer. There is a need to revaluate traditional approaches to screening and develop innovations that can be customised for the complex populations (eg, considering ethnolinguistics, migration rates, etc) across SSA. For example, a considerable number of women diagnosed with breast cancer in SSA are younger than 40 years, creating a need to adapt population screening approaches that have mostly been developed in very different high-income settings and populations. In addition, a lack of funding might not support widespread national mammographic screening programmes. Strategies that incorporate breast cancer awareness strategies and equipping health workers with skills to perform quality clinical breast examinations could have the potential to complement early detection strategies and potentially downstage cancers at diagnosis. Implementation of point-of-care molecular testing for cancer screening (eg, for HPV on the GeneXpert platform for cervical cancer screening) might be costly but a worthwhile investment if linkage to care improves. Screening techniques such as the handheld breast scanner hold potential promise for screening tools.[114] A global alliance for diagnostics can build on the essential diagnostics list developed by WHO and improve availability and affordability through market shaping. The inclusion of cancer tests in the universal health coverage scheme would also increase access to these important services.

The recent *Lancet Oncology* Commission[115] on medical imaging and nuclear medicine has highlighted the need to enhance awareness of affordable and effective cancer imaging technologies available today. The Commission reports that the benefits of scaling up diagnostic imaging for cancer in Africa would be substantial and would avert more than 35·7% of total projected cancer deaths in Africa between 2020 and 2030 and result in 61·27 million life-years saved. This finding highlights great opportunities for SSA countries to invest in and scale-up imaging. Financing for such scale up could come from public financing (ie, government budgets allocated to health) and complementary financing from the private sector.[115] Additionally, there is the potential for funding from external sources such as the African Development Bank, which see providing funds as a good investment, or from other novel financing mechanisms.

Cancer treatment

Systemic treatment

Cancer medicines are an important modality in cancer therapy in both curative and palliative settings. The most recent modelling, done by Wilson and colleagues,[116] estimates that between 2018 and 2040, the number of patients requiring first-course chemotherapy annually worldwide will increase from 9·8 million to 15·0 million, a relative increase of 53%. The estimated proportion of patients needing chemotherapy who reside in LMICs was 63% (6 162 240 of 9 782 783) in 2018 and will increase to 67% (10 071 049 of 14 984 560) in 2040.[112] Affordable essential medicines and vaccines for all by 2030 is an integral component of Sustainable Development Goal 3 (ie, achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality, and affordable essential medicines and vaccines for all). The African continent has seen expansion of access to cancer medicines in the past 10 years and more attempts at incorporating those listed in the WHO essential medicines list.[117,118] However, despite these developments, access to cancer medicines remains low in SSA due to various challenges.

In most of SSA there is weak infrastructure, fragile health systems, and inefficient market and procurement practices, which leads to an erratic supply of cancer medicines. The pharmaceutical regulatory process might also be an impediment to the availability of cancer medicines in SSA in addition to the market incentives to sell systemic therapies. Low gross national income and GDP of most SSA countries means that pharmaceutical companies have little incentive to file for regulatory approval in SSA, thus reducing access to many new drugs.[119,120] Weak national pharmaceutical regulatory bodies lead to poor pharmacovigilance and easy access for companies selling poor-quality generic cancer medicines. Finally, it is important to recognise that many cancer medicines (which might be part of standard practice in high-income countries) offer even more modest benefits to patients in SSA settings. Given the low involvement of SSA populations in clinical trials, more caution should be given when adopting international scales of benefit. These low-value treatments need to be carefully considered in all health systems and especially in SSA where resources might be more effectively deployed to ensure patients have access to medicines that offer substantial benefit compared with investments in high-quality surgery, radiotherapy, and palliative care. The European Society of Medical Oncology Magnitude of Clinical Benefit Scale can be used to objectively measure the extent to which new medicines benefit patients. This tool is now being used by the WHO essential medicines list to prioritise cancer drugs and might also be useful to health system leaders and clinicians in SSA. However, even the current essential medicines list for cancer contains many systemic therapies that might not be regarded as essential in SSA settings due to the overall costs for patients and the management needs (and also costs) of complex toxicities. Also worth considering is that poor access to supportive treatment (eg, adequate anti-emetics), facilities, and knowledge to manage neutropenic sepsis can negate the benefit of even clinically effective drugs when patients die from these complications. Another consideration is on treatment decision making, administration, and quality. These decisions should be made in consultation with the patient and, given the culture in most SSA settings, with their family.[121,122]

For recommendations in medical management, adoption of WHO's essential medicines list by individual countries is recommended to make the use of cancer medicines more cost-effective, especially if linked to a well managed procurement and reimbursement process. Harmonisation of cancer treatment guidelines in SSA has been done by the African Cancer Coalition in partnership with the American Cancer Society and the National Comprehensive Cancer Network (NCCN). Resource-stratified guidelines for SSA can guide decision makers on which medicines and associated diagnostics should be reimbursed at cancer centres. This regional collaboration could help in scaling up availability of basic packages of essential systemic therapies. The African Cancer Coalition, NCCN, American Cancer Society, and Clinton Health Access Initiative also partnered with some pharmaceutical companies to provide cancer medicines in a cancer access partnership. This partnership provides for access to approximately 20 cancer medicines across various countries in SSA.[123] This initiative is an example of how pooled procurements can help to drive down costs, which is a highly recommended approach.

Furthermore, developing funding mechanisms where finances are mobilised, pooled, and then allocated to improve access to cancer medicines should be explored in the region, drawing on pre-existing examples such as The Global Fund to Fight AIDS, Tuberculosis, and Malaria and Gavi. Cancer care providers and patients should be educated on the cost-effectiveness of generics and biosimilars. Building capacity and capability in laboratory services for biomarker testing is crucial to reduce waste and reduce costs by selecting patients who are most likely to benefit from specific therapies. With more countries embarking on universal health coverage, the inclusion of a tax-based government health coverage might reduce out-of-pocket expenses for patients and catastrophic spending for governments and patients. Workforce training in the provision of chemotherapy and supportive care will improve the use and quality of medical oncology. Initiatives, such as Choosing Wisely Africa, can also offer tools to improve compliance with evidenced-based systemic therapy that is contextually cost-effective.[124] Lastly, there is a crucial need to embed the delivery of systemic therapies into multidisciplinary teams, rather than leaving them as stand-alone practices.

Real-world evidence of the efficacy of cancer medicines in SSA populations requires investments and strengthening of cancer registries, outcomes research, and improved integration of African patients in regional and global clinical trials.[125] Harnessing information technologies and using mHealth (ie, the use of hand-held communication devices such as smartwatches, smartphones, and tablet computers for health services, information, and data collection) is a promising strategy to populate cancer registries, navigate access to care, track patients, and monitor symptoms and survival outcomes, which all might be usefully applied to systemic therapies.[126]

Geographical and financial equity in access to cancer medicines remains a major challenge across SSA, with rural populations and other vulnerable populations often deprived of access to systemic therapy. Chemotherapy requires more stringent follow-up, including toxicity assessment and patient-reported outcomes, which is often challenging in many settings. At the same time, chemotherapy is more amenable to outpatient and decentralised care options provided a well calibrated system of safety is in place. This system entails the expansion of medical oncology in regional centres and units, and the incorporation of judicious task-shifting with adequate supportive supervision. Redesigned service delivery models with attention to cancer centres, units, wards, and day-treatment centres could help to create a more integrated and robust health system similar to other models such as HIV service delivery (figure 3).

Immunotherapy has emerged over the past 10 years as a new frontier in the battle against cancer. Immunotherapy offers an effective treatment option with notable response rates in several cancer types. However, access to immunotherapies in SSA is limited by the high financial cost on the patient and the health-care system and the dearth of immune-oncology specialists. In addition to the recommendations made to increase access to chemotherapy, a scientifically based win–win approach[127,128] is greatly needed to make immunotherapies more accessible in SSA. Such an approach would mobilise stakeholders for collaborative actions that can lead to cost-effective better-value cancer care, in which all participants including patients, pharmaceutical companies, governments, and other stakeholders benefit. Furthermore, innovative scientific approaches such as the use of smart drug delivery,[129] using smaller amounts of immunotherapy in combination with other treatment modalities such as radiotherapy, are currently being investigated and should be seriously considered, including in multi-centre clinical trials that involve populations in SSA. Determining predictive biomarkers of treatment response, including via artificial intelligence methods, is of importance, since it can aid in selecting the patients who are most likely to benefit from immunotherapy.

Surgery

The *Lancet* and *Lancet Oncology* Commissions on global surgery and global cancer surgery have elegantly outlined the scope of the problem with surgical care worldwide, with the unmet need for surgical skills being greatest in regions such as SSA.[130,131] Although emphasising the paucity of services and lack of skills, there is a general scarcity of recommendations about specific strategies to adapt in SSA. There has been little support for surgeons to practice in SSA. Against the backdrop of poor supportive infrastructure and equipment, there are also insufficient numbers of support personnel to support good diagnostics, safe anaesthesia, and dedicated surgical and perioperative nursing and few opportunities to upskill after initial surgical training or for fellowship training.

In SSA, patients largely have to pay, as they do for other modalities, out of pocket for surgical services. The global cancer community can no longer ignore the financial toxicity faced by patients or the catastrophic health expenditure without considering the deeper drivers of these systems such as lack of political support and goodwill. Unfortunately, various attempts at universal health coverage on the African continent still offer only a cursory nod to surgical services, and there is heterogeneity and there are limitations to the services covered. Time and circumstance have shown, since Halstedian times in the 1900s, that the oncology surgeon operating in isolation is bound to have poorer outcomes than one operating in a team. A multidisciplinary approach to care is often missing, which means that preoperative optimisation of patients is less likely to occur. Complex oncological surgical procedures requiring advanced postoperative support to achieve good outcomes might not be feasible where these services are unavailable. Data from the African Surgical Outcomes study and other sources have shown that the perioperative morbidity and mortality in

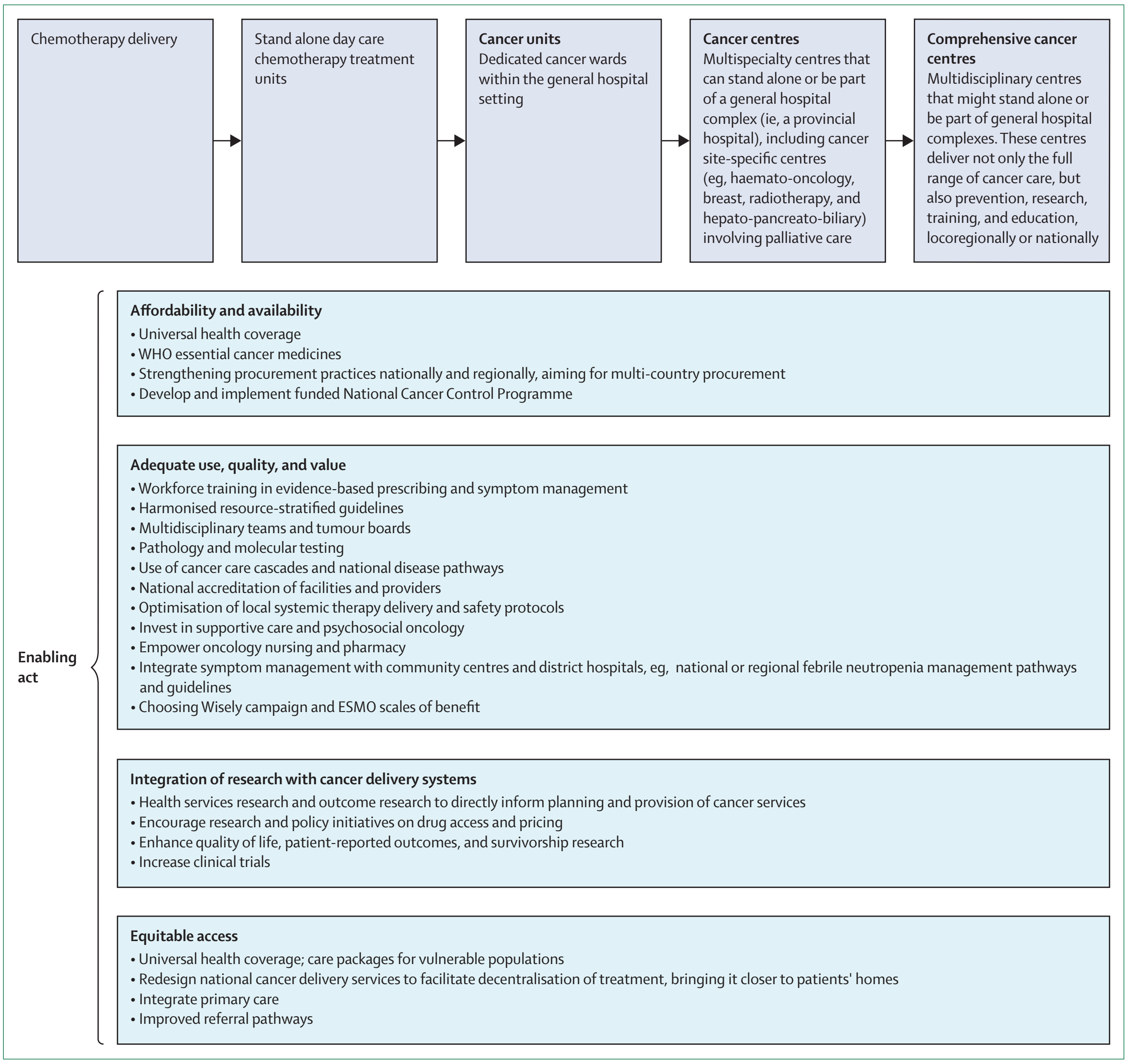


Figure 3: **Recommendations for scaling up of systemic therapy delivery in sub-Saharan Africa**
ESMO=European Society for Medical Oncology.

SSA is substantially higher than in the rest of the world even for routine procedures, with patients at low-risk in SSA twice as likely to die in the postoperative period than those in the rest of the world.[132,133] The foundations of safe surgery, such as diagnostics, are essential to determining aspects of resectability and risk of recurrence, among other outcomes. Additionally, radiotherapy as adjuvant or neoadjuvant therapy complements good surgery, enabling organ sparing, less disfiguring surgery, and reduced recurrence rates. These outcomes speak to the need for more integrated tri-modality care in SSA working with skilled, well-trained surgery teams.

In considering recommendations, the expansion of surgical capacity in SSA should include strategies that will teach new surgical oncologists specialised techniques and homogenise the skill sets of the existing surgical workforce, including general surgeons. A pragmatic approach to ensuring cost-effectiveness of care must guide the skill set priorities. Minimally invasive surgery might be expensive upfront, but leads to reduced length of hospital stays for some patients. However, a firm grounding in the tenets of open oncological surgery must be the sound building blocks on which any attempts to develop more sophisticated surgical strategies in SSA should rest. The need for more surgical expertise that can manage open procedures, whether this is general or pelvic, runs counter to increasing training and the use of more minimally invasive and robotic-assisted procedures. Following a high-income driven training model for surgical expertise in SSA runs the risk of over-specialisation.

Establishing regional and national centres of excellence in SSA to provide training for oncological surgical skills must be accompanied by health systems and implementation research that iterates and improves care delivery in different systems. Mandatory surgical audits ensures reflection on practice and an objective way to assess performance and delivery of surgical care. A culture of transparency and openness driven by a robust morbidity and mortality auditing process, that shifts the focus away from blaming the individual surgeon and towards optimising surgical outcomes for patients, must be established.

Wage discrepancies often lead to tensions between private and public practice, resulting in less engagement and motivation of surgeons to provide public services, negatively affecting ethical practice, especially in settings that do not have robust governance and where there are no consequences for malpractice. Therefore, a frequently unacknowledged prerequisite to success lies in adequate remuneration of health workers, including surgeons, with minimal wage discrepancies.

To establish centres of excellence for surgical oncology, regional or continental bodies of accreditation should be a requirement to establish minimum standards in the context of the available resources. Mentorship, support, and collaboration with international surgical oncology bodies should be coordinated at regional and interregional levels to drive concerted efforts to improve outcomes. There is an excellent opportunity at this time to change the paradigm on how to train, deliver surgical care, and potentially improve skills through international collaboration. In a setting of greater regional collaboration and cooperation through funding agencies such as the African Union, cancer centres built on multidisciplinary training for the workforce and the provision of financial support for research and patient care is the ideal model for surgical oncology training. Performance metrics for evaluation should include key indicators such as the number of lymph nodes harvested, completeness of resection, and patient-reported outcomes to address the quality of cancer surgery. In addition, such centres would need to incorporate matrices that address the unique challenges to oncology care in SSA, such as retention of patients in the health system, completeness of care, and long-term follow-up after treatment.

Radiotherapy

In the next 15 years, Africa is estimated to require at least 5000 additional megavoltage radiotherapy machines to ensure equity in cancer care.[134] Until recently, traditional Cobalt-60-based radiotherapy was the standard of care across Africa due to ease of functionality and cost-effectiveness. Demands for access to linear accelerators have increased across the continent in recent years. The International Atomic Energy Agency (IAEA) data for 2021 estimates that 420 radiotherapy machines are operational or in service in 32 countries in Africa,[135] but the majority (>80%) are in southern and northern Africa. Brachytherapy, a vital treatment component of one of the most common cancers in Africa (cervical cancer) is in short supply.[136] As of 2014, less than 50% of African countries had brachytherapy equipment, with 75% of these located in South Africa, Egypt, and Morocco—all countries with relatively higher gross national income per capita and stronger health systems than other African nations.[137] Many countries are either expanding access or attempting to commence radiotherapy programmes, which includes transitioning to more complex radiotherapy delivery such as high dose rate brachytherapy. Paucity of political commitment to purchase and maintain equipment, high running costs, and unstable electricity supply are challenges shared by most countries in Africa.[138,139] Loco-regional training of a skilled radiotherapy workforce ensures sustainability, reduces brain drain, and is highly cost-effective, as can be attested by many African countries such as Kenya and Tanzania. Clinical oncologist, medical physicist, radiotherapist, and dosimetrist training programmes are increasing in number, with a subsequent boost to numbers of medical professionals skilled in the delivery of radiotherapy. However, the IAEA recommendation of one oncologist per 250–300 patients per year remains unattainable in most African countries, with many only having one to two consultants for large populations, with negative consequences for output, quality, and care.[140]

Access to radiotherapy is not only limited by staff numbers and machine availability. Additional barriers include remoteness from a treatment centre, financial difficulties, poor diagnostic and pathology services, and the complexities of stable electricity supply and engineering backup to ensure the equipment is running properly. Given the low number of machines, modifying treatment regimens to allow access for more patients includes a preference for hypofractionated schedules, especially for palliative treatment. Examples of these can be found in innovative African studies such as the study by Deressa and colleagues[141] from Ethiopia, which showed that 2D hyperfractionation with Cobalt-60 radiotherapy in the palliation of patients with oesophageal cancer was effective and feasible. Adaptation of hypofractionated regimens in the curative setting allows greater throughput of patients and substantial cost savings for patients who pay out of pocket per fraction.[142] However, Cobalt-60 radiotherapy is technically difficult to administer without conformal planning, and high integral and skin doses increase toxicity. A few countries within the region outside north and south Africa, such as Rwanda, have access to advanced radiotherapy techniques, including volumetric modulated arc therapy and have set up remote planning hubs through international cooperation with institutions in high-income countries. Volumetric modulated arc therapy reduces patient treatment waiting times and patient-related toxicity but is labour-intensive, especially with a small workforce. Moreover, linear accelerator-based facilities in Africa often experience downtime associated with failures in multileaf collimators and vacuum pumps, as well as power instability.[143]

In considering recommendations for radiotherapy, it is important to emphasise the fact that radiotherapy is a critical and inseparable component of comprehensive cancer care, and there is compelling evidence that investment in radiotherapy not only enables treatment of large numbers of cancer cases to save lives, but also brings positive economic benefits.[134] Atun and colleagues[134] reported that operating costs in low-income to upper-middle-income countries range from US$60–86 per fraction in comparison to $235 per fraction in the high-income setting, guaranteeing a higher return on investment in radiotherapy in low-income than in wealthier nations. We therefore strongly recommend that governments, private industries, non-governmental agencies, and other stakeholders invest in or scale up radiotherapy resources in SSA with increasing urgency to address the surging numbers of cancer cases, and increase access to better value care. The Government of Botwsana's investment in the Gaborone Private Hospital represents one excellent example where the government achieved best value and decreased costs relative to referrals outside the country through a public–private partnership.[139] It is also important that cancer treatment facilities in SSA be planned with brachytherapy facilities in mind, given the great need for the treatment of advanced cervical cancer. Given that maintenance of equipment can be a major drawback for radiotherapy service provision in Africa, comprehensive service and ongoing maintenance contracts, which are key to reducing downtime, should be considered a priority when acquiring radiotherapy machines. Investment in back-up power supply such as electricity generators, or even solar power,[144] is also recommended. Human capacity is critical for successful radiotherapy including the oncologist, medical physicist, radiotherapist, oncology nurse, and access to engineering support. Recently instituted training programmes that have successfully led to rapid expansion of the workforce, for example in Tanzania with approximately 30 graduates in the last 5–6 years, need to be emulated to address shortfalls in human capacity. Quality management and assurance also needs to be emphasised and prioritised to ensure safe use of radiation technologies, including through SSA governments recognising the crucial role that medical physicists play and establishing effective national regulatory infrastructure to ensure safety, working with the IAEA.

Safety and quality of cancer care in SSA

Quality of care incorporates the safety of care delivery while ensuring equity, timeliness, appropriateness, efficacy, patient satisfaction, and sustainability.[145] Good cancer care involves complex integration of diagnostic and therapeutic modalities including imaging, pathology, surgery, radiotherapy, and cancer medicines. These services require regulation and skilled application to avoid untoward outcomes balanced with clinical benefit. Additionally, cost-effectiveness is an essential component of quality of care. Major hindrances to quality cancer care delivery across SSA mirror those in many LMIC settings, including inadequate infrastructure and lack of maintenance culture for essential equipment, a scarcity of skilled human resources, low prioritisation of cancer services, poor regulation, substandard reagents and medications, high out-of-pocket payments, corruption or lack of accountability, limited health budgets, and poor access to cancer services. Here we discuss the possible strategies to address existing gaps in quality care delivery, and propose contextual benchmarks based on Donabedian's[146] framework for quality of care.

Cancer facilities are typically found in major cities, inaccessible to many vulnerable patients. It is essential that aspects of cancer care be safely decentralised. Delivery of care could be redesigned with initial consultations in major centres and subsequent follow-up and delivery of chemotherapy in adequately resourced peripheral centres. Financial stability for care delivery centres is key and must involve a regulated private sector and civil societies to reduce the burden on governments. Procurement processes for infrastructure that preclude the end user and stakeholder input often result in redundancy and waste of scarce resources. Investments in local training facilities and multidisciplinary care is important.

Improving access requires increasing the number and quality of the cancer care workforce and better integration with research and practice involving primary care workers to help with prevention, navigation, palliation, and surveillance. Reducing burnout and psychological distress in the workforce is an internal marker of quality and safety. Universal health coverage for cancer control is an important step towards improving access to quality and safe care. Procurement of logistics for cancer care must be led by cancer specialists. The development of local context and adoption of harmonised evidence-based, cost-effective, and pragmatic cancer management guidelines will ensure sustainable and effective interventions to all patients at all times. Academic organisations such as the African Organisation for Research and Training In Cancer (AORTIC), and other regional societies stimulate research, share best practices, solutions, and challenges, and develop quality assurance benchmarks to improve quality of care across the cancer care continuum. Formation of regional and interregional consortiums for oncology specialties will demand quality outputs such as quality of testing kits, laboratory reagents, reporting systems, imaging, and pharmacy practices, including strengthening pharmacovigilance for cancer medicines. International collaboration must prioritise human resource training, ensuring skill transfers to build capacity, quality, and safety. Promoting patient support and survivorship groups drives

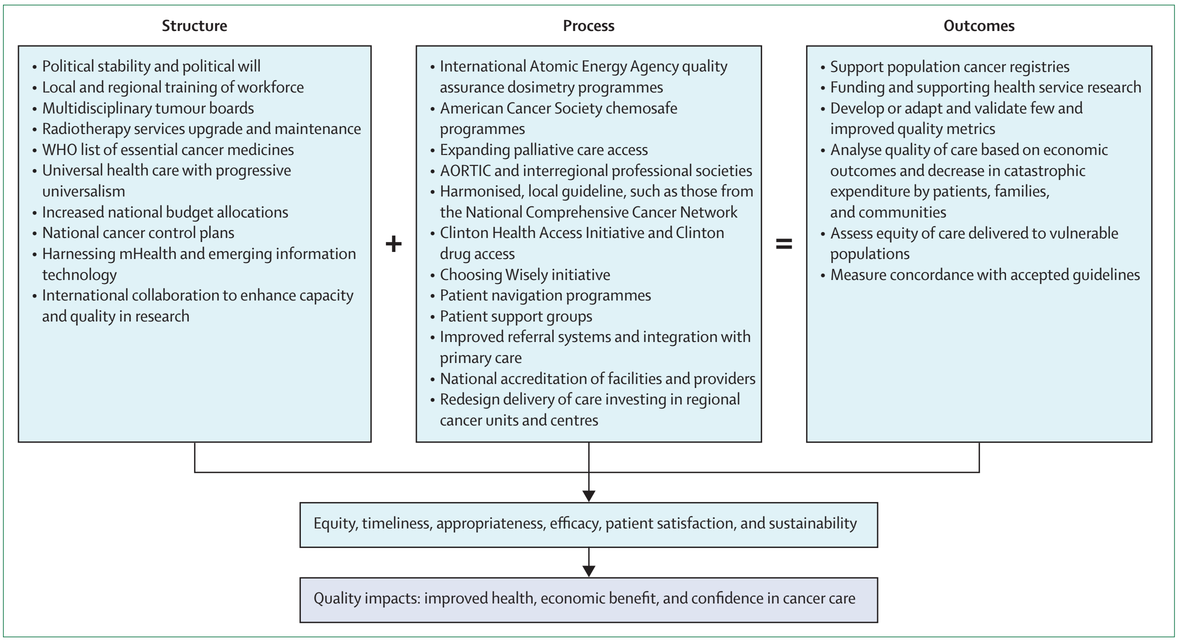


***Figure 4:* Quality of cancer care in Africa framework capturing existing and proposed activities and initiatives**
Adapted from the Institute of Medicine and the *Lancet Global Health* Commission.[147] AORTIC=African Organisation for Research and Training In Cancer.

improvement in outcomes. Systems should be put in place to measure outcomes (short term and long term) such as survival, patient-reported outcomes, positive surgical margin rates, and toxicity to facilitate continuous quality improvement. Governance and accountability of cancer care institutions should be strengthened to encourage data capture, to develop benchmarks that measure quality and feedback mechanisms to improve care. Developing magnitude of benefits scales for cancer care interventions adapted from high-income countries and prioritising health services research could potentially improve the quality and safety of care (figure 4).

Next steps

The development of regional Afro-centric solutions that address the unique concerns for treatment and care of patients in this environment must be the priority. Key concerns such as patient navigation to ensure treatment compliance is critical to improving long-term outcomes. Traversing national boundaries and developing regional axes of negotiation for cancer services could be mediated through regional bodies such as the African Union. The economic argument around health and cancer services, the need to look beyond traditional funding revenue streams, and the development of sustainable social enterprises and innovations can potentially address health concerns in low-income countries in SSA. Innovations can improve resource use, improve quality and outcomes, and optimise the use of human resources. Table 5 highlights the challenges, successes, and opportunities to consider going forward, while panel 7 highlights the key messages of cancer screening, diagnosis, and treatment.

Section 4: palliative care for oncology

Palliative care is best understood as an approach that aims to alleviate preventable suffering for patients with serious illness along with their families and communities.[150–152] Palliative care is an essential element of cancer care.[5] Palliative care is often misunderstood as synonymous with hospice care or limited to the end of life. Although palliative care needs might intensify at the end of life, they can be integrated through all phases of care, from diagnosis to end of life and on to bereavement. Palliative care can include pain and symptom management, psychological and mental health support, social and economic support, and legal and logistical support. Patients with potentially curable disease benefit from palliative approaches. Further, early integration of palliative care into standard oncology care has been found to have many benefits for patients with metastatic disease. In fact, a survival benefit with palliative care was found for patients with metastatic non-small-cell lung cancer in one landmark randomised clinical trial.[153]

In 1993, Anne Merriman founded Hospice Africa Uganda, introducing a model system of terminal care customised to low-income countries with limited resources.[154] From Hospice Africa Uganda, the Palliative Care Association of Uganda grew and became a founding member of the African Palliative Care Association. Today, most countries in SSA have at least some specialist-led, palliative care services that include community-based, hospital-based, and hospice-based care.[151] The largest numbers of individual services are concentrated in Uganda, South Africa, and Kenya, whereas the highest concentrations of services per capita are in Swaziland,

	Challenges	Successes	Opportunities
Screening and diagnosis	High cost of screening and diagnostic equipment such as mammography devices; low number of specialists, such as pathologists, to operate sophisticated equipment for screening and diagnosis; low sensitisation and awareness among health-care providers about availability and the importance of cancer screening; low standards of living do not permit people to spend money on screening services in the midst of other urgent financial obligations; a lack of health insurance to cover screening means that people must pay upfront and out of pocket; inadequate access to specialised ancillary testing in cancer (examples include immunohistochemistry, flow cytometry, molecular testing, and PET-CT); poor-quality metrics such as turnaround times and specimen handling for cancer diagnosis need to be improved to have a meaningful impact; minimal investment in cancer diagnostics	Wide use of a visual inspection method to screen for cervical cancer, a method that bypasses sophisticated laboratory infrastructures; countries are now developing national guidelines for screening and diagnosis eg, in Cameroon and Tanzania; in Tanzania, screening, early diagnosis, and treatment using cryotherapy is done in every district for free; countries such as Kenya have developed national specimen handling guidelines specifically for cancer; use of postal transport services in Uganda for streamlining specimen transport to referral centres; provision of support through telepathology to pathologists and technologists in Rwanda to build local capacity in cancer diagnosis; inclusion of crucial cancer tests eg, oestrogen receptor, progesterone receptor, and HER2 (also known as ERBB2) for breast cancer in WHO's 2nd Essential Diagnostics List[148,149]	Develop cancer screening audiovisual aids in local languages; integrate cancer screening into routine outpatient care; more research into cancer screening and diagnosis; widespread implementation of telepathology to support pathologists; use of mobile health applications to improve turnaround times for cancer diagnosis; strengthen national population-based cancer registries to inform investment in cancer diagnostics; use of artificial intelligence algorithms for cancer screening (eg, mammographical breast cancer screening); investment in centralised specialist diagnostic centres; expand the range of cancer tests in the next version of WHO's Essential Diagnostics List
Medical therapy	High cost of cancer medicines; low purchasing power of countries; high out-of-pocket expenditure for cancer medicines for patients; waste of resources by prescribing low-value, high-cost cancer medicines; weak procurement systems; low capacity of pharmaceutical regulatory companies leading to poor pharmacovigilance and influx of poor-quality generic medicines; centralised medical oncology services; influence of some traditional and faith healers (eg, faith healers sometimes spend a long time praying for the patients and might only encourage them to go to the hospital when it is already too late)	Initiation of cancer medicines access programmes (assisted by the Clinton Health Access Initiative); in Tanzania, the government is financing treatment and patients are receiving chemotherapy and radiotherapy for free; universal national health insurance is covering cancer care (in Rwanda) and part of cancer drugs, surgery, chemotherapy, and radiotherapy (in Kenya); harmonisation of guidelines for SSA; an increase in local training programmes for oncologists and nurses in the past 10 years	Leveraging on the cancer medicines access programmes and pooled procurements can drive costs of cancer medicines down; pooled funding that can be directed to specific cancer care aspects; use of WHO's essential medicines list and the European Society of Medical Oncology's magnitude of clinical benefit scale to prioritise cancer drugs to ensure maximal use of resources; decentralisation of medical oncology with task shifting and supportive supervision
Surgical management	Insufficient skilled training in surgical oncology; lack of homogeneity in skill sets of surgeons; out-of-pocket payments for treatment; poorly motivated surgeons in terms of remuneration; lack of opportunity to scale up their surgical skill after training; lack of access to multidisciplinary teams	Regional oncoplastic breast surgery training facilitated by the Pan African Women's Association of Surgeons and the Surgical Society of Kenya supported by the Association of Breast Surgery; breast and colorectal surgical preceptorships; the African Research Group for Oncology Collaboration–Colorectal Consortium to enhance training and research in cancer; the building of a urology network to improve urology surgery in francophone countries in SSA; cancer surgery is free in Ghana; improved access to diagnostic facilities—colonoscopy, CT scan, and MRI in parts of Africa such as Ghana and Côte d'Ivoire	Leveraging surgical oncology training through regional colleges; development of collaborative networks with national, regional, and international surgical oncology societies; introduction of minimally invasive surgical techniques to cancer management; introduction of organ-sparing surgery
Radiotherapy	Access to radiotherapy is low or not available in many countries; lack of skilled personnel; limited access to teaching and training; high cost of maintenance of equipment leading to frequent downtime; high cost of user fees limits access for patients in some regions	Increased access to linear accelerator-based radiotherapy in many regions; expansion of training programmes; remote radiotherapy planning hubs provide support for centres with limited access to skilled personnel; International Atomic Energy Agency support for training on the continent; universal health care covering radiotherapy costs in some regions; decentralisation of radiotherapy services in different countries and government support for treatment eg, in Tanzania and Rwanda	Regional cooperation to provide access to treatment; regional training centres increase throughput of skilled oncologists, radiographers, and physicists; research networks to develop appropriate guidelines and treatment pathways in Africa
Safety, quality, and value of care	Few standards in care delivery that are enforceable	Quality assurance teams are in place in Tanzania, and help to improve quality of care given in public institutions; international accreditation of different hospitals in SSA as quality metrics eg, Joint Commission International Africa in Kenya and South Africa; development of harmonised guidelines by the African Cancer Coalition and the National Comprehensive Cancer Network; the ChemoSafe initiative to improve the quality of preparation of chemotherapeutic agents and the safe delivery of chemotherapy by nurses; Choosing Wisely Africa published in 2020[124]	Implementation of harmonised guidelines; implementation of the Choosing Wisely initiative; dissemination of quality metrics matrices to inform national and regional centres of cancer care provision

SSA=sub-Saharan Africa.

***Table 5:* Challenges, successes, and opportunities in cancer care in SSA**

Uganda, and The Gambia. However, true integration between palliative care and cancer care efforts in practice has been slow, although this assimilation is a current priority of many existing national efforts.[10,11] Further, many dedicated cancer control efforts in SSA do not often explicitly include palliative care, instead focusing on curative therapies.[12] Although advocating for palliative care alone[13] would be unethical, the full complement of prevention, treatment, and palliation interventions should be mapped onto short-term and long-term

Panel 7: Key messages on screening, diagnosis, and treatment

1. Priority should be given to screening for preventable cancers such as cervical cancer through sustainable comprehensive national cancer prevention programmes, with an emphasis on primary and secondary preventions
2. The WHO essential medicines list should be adopted along with harmonising and implementing treatment guidelines towards improving regional quality of care and implementing evidence-based tailored treatment options for sub-Saharan Africa
3. Leveraging regional blocks procurement rather than individual countries could help to improve pricing and negotiation for cancer medication and equipment
4. Establishing regional and national centres of excellence to provide training, which could help to address workforce deficits, is encouraged along with upskilling for the existing workforce
5. Multidisciplinary management of all patients with cancer should become standard of care; strategies and innovations such as telemedicine and mobile apps should be used to bridge deficits; disease management teams must regularly reflect on their patient outcomes
6. Regional and continental bodies of accreditation should be developed for facilities to be recognised at various levels, including cancer centres of excellence to establish minimum standards in the context of available resources for low-income and middle-income countries
7. Cost-effectiveness is an essential component of the quality and value of care and prioritisation for treatment decisions should be aimed at strategies that will provide more access to many patients
8. Strengthen referral pathways and the bidirectional flow of patients to increase access to treatment facilities for patients; both in-country and external pathways for knowledge exchange and patient and clinician movement must be developed, supported, and maintained
9. Innovative strategies and those that can reduce treatment time and costs should be used or adapted to enhance care delivery to patients
10. Innovations are not a substitute for dysfunctional health systems; political goodwill and support are critical and universal health coverage remains essential. There is a need to increase investment in social enterprises that build and strengthen health financing for populations and that build solutions that are sustainable to ensure all aspects of care are supported, such as microfinancing for patients and survivors to support businesses to ensure support of treatment completion
11. Advocate for government investment in cancer diagnostics and reimbursement for core cancer tests, which are crucial components of effective cancer care
12. Mobilise advocacy for global funds to cancer care; priority should be given to the entire cancer care continuum

NCCPs. Cancer plans and programmes should explicitly recognise that surgery, chemotherapy, and radiotherapy can all provide meaningful palliation for patients with cancer.[1,8,14–17]

All patients with serious illnesses, including cancer, benefit from early initiation of palliative care. Yet, specific palliative care need in oncology can also be estimated by modelling demand for core medications and services. Several studies have estimated the need for pain relief in palliative care by using the number of 90-day oral morphine courses as a measure.[150,151,155–157] This method can be applied to cancer care specifically using the IARC Global Cancer Observatory Data on national cancer prevalence and mortality estimates (figure 5A). In 2018, an estimated per-country median of 4862 (IQR 1085–9114) 90-day oral morphine courses were needed for all people who died from cancer in SSA. A further per-country median of 1079 (IQR 487–3670) 90-day courses were needed that year for patients living with cancer. For all SSA countries in 2018, this number was an estimated total of 405 745 90-day courses for decedents, 164 824 for people living with cancer, and 570 569 courses overall. In 2030, 6884 per-country median 90-day courses (IQR 1495–14 825) are predicted to be needed for all people who die from cancer in SSA, a total of 612 479 courses across SSA. There are insufficient data to estimate the need for people living with cancer. Although complete, per-country data on oral morphine prescriptions are not available, previous studies suggest that access remains poor.[155]

Another estimate of palliative need that is specific to oncology is the need for palliative radiotherapy.[158] The methods used to estimate overall radiotherapy needs can be applied to palliative radiotherapy indications by including the percentage total courses that are estimated to be needed for palliation. The length of radiotherapy courses cannot be easily estimated, although international and regional guidelines suggest short courses (one to five treatments) would be preferred. In 2018, an estimated median of 2571 palliative radiotherapy courses per country (IQR 738–5346) were needed, for an estimated 243 903 total courses (figure 5B). In 2030, the median number of per-country palliative radiotherapy courses needed will rise to an estimated 3858 (IQR 1077–8206), for an estimated 360 121 total courses. However, as discussed previously, many countries in SSA do not currently have any access to radiotherapy. For countries with radiotherapy access, the number of patients who could benefit from treatment often outstrips the current machine capacity and staff availability.

Enhancing palliative care in oncology in SSA via the 5S framework

We recommend leveraging the 5S framework (appendix p 9) to improve access to palliative care in oncology in SSA. This 5S framework considers staffing, stuff (ie, equipment and consumables) and services, space, systems, and synergies.[158] In terms of staff, more oncology palliative care staff in SSA need to be trained. Improving access to palliative radiotherapy critically depends on access to training. Meanwhile, stuff or services includes drugs, radiation machines, other palliative treatments and procedures requiring consumables and technology commodities. In SSA, reliable and cost-effective palliative care can be provided for most patients using radiotherapy.[158] The use of advanced information and communication technologies for palliative care should be extended via tele-radiotherapy to improve both quality of, and access to, services. National and institutional protocols should be established for securing stuff such as medication and technologies needed for palliative care delivery. The concept of space refers to home, primary health centres and health posts,

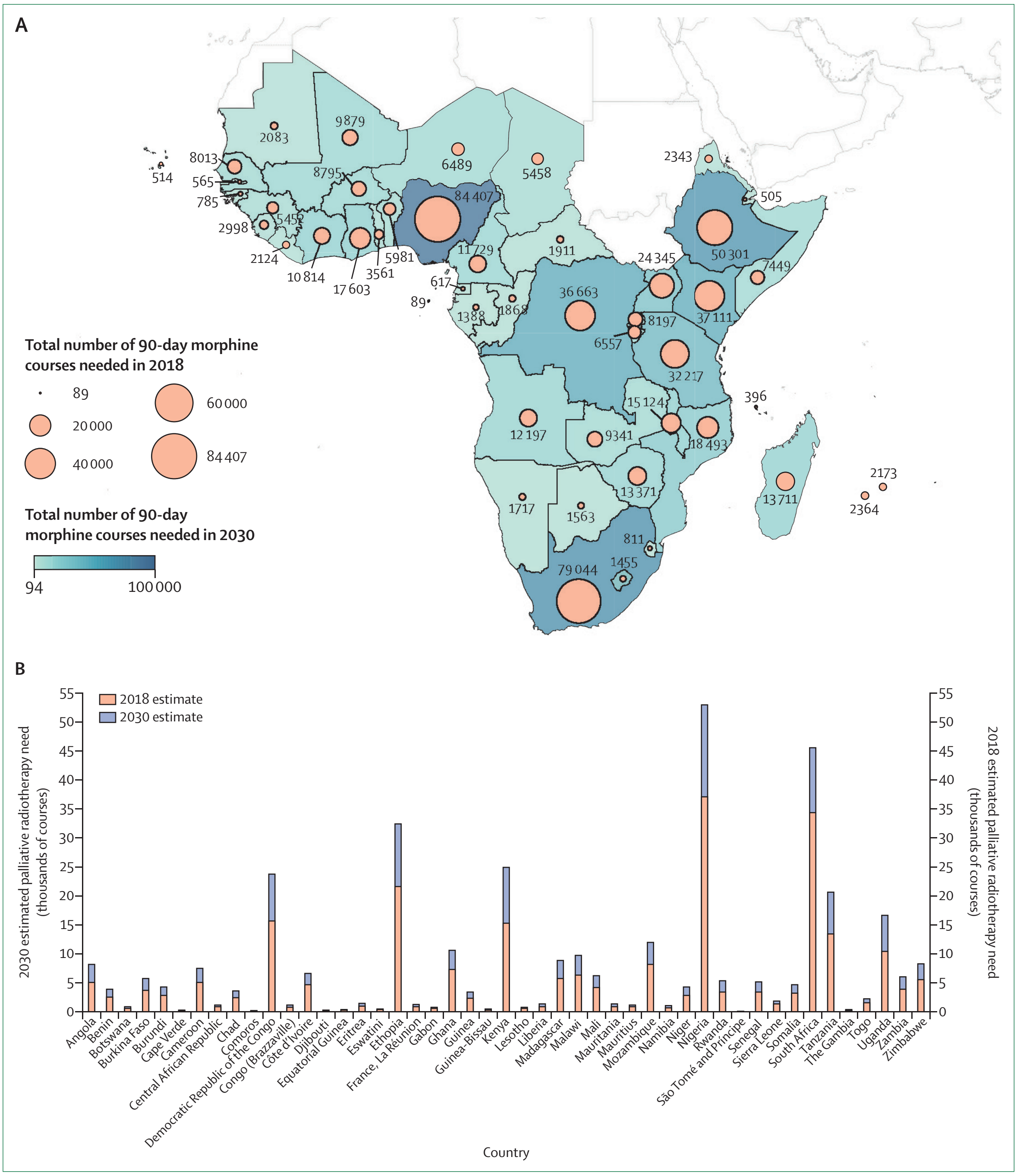


Figure 5: **Palliative care course estimates for sub-Saharan Africa**

(A) Estimated 2018 and anticipated 2030 number of 90-day morphine courses per country for cancer pain. (B) Estimated total number of palliative radiotherapy courses needed by country in 2018 and 2030 (information not available for Sudan).

hospices, outpatient clinics, and hospitals. In addition to space for stuff and services such as radiotherapy, space should be designated for patient and family-caregivers, given that most of them have to travel long distances to receive care such as radiotherapy. Under systems, palliative radiotherapy should be included in health-care system referral. SSA should also consider the use of information and communication technologies including: mHealth, EMRs, and teleoncology.[159,160] Finally, with respect to synergies, oncology services should be better integrated to break down traditional disciplinary barriers and facilitate the optimisation of available human resources and reduce costs. For example, palliative radiotherapy should be more integrated to synergise with

	Target	Timeline to be achieved by
First tier priorities		
1	Implementation of *The Lancet's* Commission for Global Pain and Palliative Care basic package[161] and the American Society of Clinical Oncology's resource-stratified guidelines[162]	2023
2	Implementation of model palliative care services[161] to improve the quality of life of patients with cancer and their families	2023
3	Palliative care research—patient-reported outcomes and descriptive studies	2023
4	Explicit integration of palliative and urgent radiotherapy	2024
5	Core palliative care competencies for all health systems staff	2024
6	Telephone-based mHealth and telehealth support	2025
7	Basic electronic medical records	2025
Second tier priorities		
1	Implementation of *The Lancet's* Commission for Global Pain and Palliative Care enhanced package[161] and the American Society of Clinical Oncology's standard palliative guidelines[162]	2030
2	Action plans for stereotactic palliative radiotherapy services	2035
3	Palliative care research—clinical trials	2035

Table 6: **Key targets for implementation of community-based palliative oncology in sub-Saharan Africa**

surgical and medical oncology, and palliative care services for other diseases such as HIV and AIDS. Looking ahead, table 6 highlights the key targets for community-based palliative oncology implementation and panels 8 and 9 present examples.

For more on the **International Society of Paediatric Oncology Global Mapping project** see https://siop-online.org/globalmapping/

Section 5: paediatric oncology

In 2018, nearly 460 million SSA children younger than 15 years of age accounted for 42·5% of the total population.[169] Since nearly all SSA countries have seen a decline in infection-related childhood mortality in the past few decades,[170] cancer now accounts for a growing proportion of SSA childhood deaths. Although precise estimates of the burden of childhood cancer in Africa are unavailable, the International Incidence of Childhood Cancer-3 estimated an incidence in SSA of 56·3 cases per million population.[171] This estimate was based on only six SSA national cancer registries meeting stringent quality criteria (ie, La Réunion, Kenya, Mauritius, South Africa, Uganda, and Zimbabwe) covering only 5·1% of the region's children. The AFCRN compiled data from a broader range of registries;[172] incidence estimates ranged from 27·6 (The Gambia) to 308·2 per million (Malawi). Figure 6A shows the AFCRN estimates from the International Incidence of Childhood Cancer-3 in SSA, with Canada as a high-income country with universal health coverage for comparison.

Even where high-quality registries exist, they are unable to account for either undiagnosed or unregistered cases.[175] Two recent models have attempted to quantify such cases. Johnston and colleagues[173] applied American incidence rates to other countries, adjusting for malaria prevalence and its consequent effects, Burkitt lymphoma, and Kaposi sarcoma. Ward and colleagues[174] developed a microsimulation model built on International Incidence of Childhood Cancer-3 data that also used measures of general health system access and referral to estimate undiagnosed cases. The annual numbers of total childhood cancer cases (diagnosed and undiagnosed) estimated by these models are compared to GLOBOCAN estimates of diagnosed cases in figure 6B. The wide range represented by these estimates, each with its own limitations,[176] severely hampers determination of the extent that variations within SSA or between SSA and other regions could be real, or rather due to differences in diagnosis and reporting. Data on survival are even more scarce. CONCORD-2, which estimated global survival from childhood leukaemia, included virtually no SSA registries.[177] Ward and colleagues[178] modelled global childhood cancer survival by incorporating non-cancer measures of treatment availability, completion, and quality. Estimates of 5-year net survival among diagnosed cases were only 19% in southern Africa and 8% in both eastern and western Africa.[178] Although higher quality data are urgently needed, several conclusions can still be drawn: the burden of childhood cancer in SSA is substantial, the incidence in some parts of the region might exceed that of high-income countries, and survival across much of the continent is dismal. Current projections show that Africa will account for nearly 50% of the global childhood cancer burden by 2050, necessitating immediate efforts to confront this challenge.[174]

The ongoing International Society of Paediatric Oncology Global Mapping project, initiated in 2018, has considerably increased our knowledge of available childhood cancer services in Africa. It has also highlighted glaring gaps and disparities—for example, 15 countries report no trained paediatric oncologists at all. Countries such as South Africa and Kenya are able to provide a wide variety of services, ranging from high-level molecular diagnostic investigations and targeted therapies to specialised neurosurgery, whereas others such as Equatorial Guinea, The Gambia, South Sudan, and Chad have no paediatric oncology services (figure 7). Importantly, the presence of such services in a jurisdiction does not guarantee accessibility to the entire population, as many are available only to those with private medical insurance.

Proximal factors limiting delivery of childhood cancer services

Many challenges hamper the delivery of high-quality, accessible childhood cancer services. Causes of treatment failure such as diagnostic delay,[179] treatment abandonment,[180] and toxicities[181] are well described. However, these proximal causes are underpinned by deficiencies in health-care systems, which must be addressed to achieve population-level improvements in outcomes. Of note, although many of these factors apply to children and adults with cancer, their effect on paediatric cancer is often magnified given their lack of priority, or mention, in NCCPs.

A high proportion of African children with cancer have advanced disease at presentation to specialised paediatric oncology units.[179,182–184] Although often attributed to caregiver health-seeking behaviour, recent studies have suggested that parents present children early and often to health services.[185] However, inadequate awareness of cancer by front-line health-care workers, understaffing of primary health facilities, and lack of referral mechanisms results in prolonged intervals before children with cancer reach appropriate treatment centres.[179,186] Traditional healers are also often accessed, for whom recognition of possible cancer might also be difficult.[184]

Various factors, such as malnutrition, contribute to an increased risk of toxicity and treatment-related mortality of children treated for cancer in SSA.[181] The use of treatment protocols imported from high-income settings, inappropriate for a setting with limited supportive and intensive care capacity, might also contribute to increased toxicity.[187] Efforts to address this risk include the development and use of adapted treatment regimens.[188] Adapted regimens take into account the inadequate amount of supportive care capacity and issues with drug availability in many LMICs by decreasing the intensity of treatment in ways that nonetheless preserve substantial chances of cure. A key example relates to Burkitt lymphoma, which in high-income countries is treated with very high-intensity, multi-agent regimens that require substantial supportive care often including intensive care unit support, with cure rates exceeding 90%. However, monotherapy Burkitt lymphoma treatment regimens developed and tested in SSA still cure more than 50% of children.[182] Wilms tumour can also be satisfactorily treated with decreased dose intensity and increased time intervals between doses.[189] Even when appropriate protocols are used, toxicity remains a major concern. Many children are at increased risk at presentation, with a prevalence of under-nutrition ranging from 11·4% to 21·1% in SSA.[190] Malnutrition affects the ability of children to tolerate chemotherapy, affecting the pharmacokinetics and pharmacodynamics of such treatment.[181] Inadequate human resources and a scarcity of supportive care drugs also play a substantial role.

Treatment abandonment contributes to the low survival rates of childhood cancer in the region.[180] Abandonment rates of 54% in Kenya and 46% in Zambia have been documented.[191,192] Underlying reasons include intolerable stigma, inability to pay for treatment, and high transport and accommodation costs. A systematic review of treatment abandonment in SSA found abandonment was also associated with not being in a research study, low maternal education, parental unemployment, fears about treatment, and thinking that the child was well.[180] As an example of costs, asparaginase is a core component of acute lymphoblastic leukaemia treatment regimens, and its omission has been shown to compromise cure rates.[193] Asparaginase, however, is an extremely expensive medication that in Africa, using Ghana as an example, could cost as much as US$80 per dose to a total of US$960 in the first month of treatment. In comparison, the mean family income in Ghana is US$480 per month.[194] As discussed later, abandonment should be thought of as a systemic issue and not as an individual decision.

System-level factors

In SSA, there are 0·1 physicians per 1000 people, in contrast with 2·2 per 1000 in Latin America, 2·6 per 1000 in North America, and 3·4 per 1000 in Europe.[195] According to the International Society of Paediatric

Panel 8: Palliative care in Kenya

In 2019, Kenya launched its first ever Cancer Policy (2019–30) that provides a framework to comprehensively address cancer control in Kenya through the systematic implementation of evidence-based interventions for prevention, screening, timely diagnosis, treatment, survivorship and palliative care, financing, monitoring, and research. The Ministry of Health has developed several clinical guidelines to standardise cancer treatment, palliative care, and survivorship. These include National Cancer Treatment Protocols in 2019,[163] which built on the National Palliative Care Guidelines of 2011, and included palliative care for children and adults. The specific cancers covered are Kaposi's sarcoma and breast, central nervous system, gastrointestinal, gynaecological, head and neck, haematological, lung, prostate, and paediatric cancers. The treatment protocols also complement the National Guidelines for Cancer Management in Kenya released in 2013. The National Guidelines for Establishment of Cancer Centres also include palliative care requirements: human resources, essential palliative care medications including opioids, and other essential commodities.[164] A National Palliative Care training curriculum has also been developed,[165] which is an important part of staffing in the 5S strategy.[159] Palliative care has been integrated into 78 health facilities in 42 of the 47 counties in Kenya in collaboration with the Kenya Hospices and Palliative Care Association. Survivorship has become an important aspect of cancer care and, as cancer care improves, there is a need for better care planning for survivors of cancer. Cancer support groups have been established within communities for psychosocial support and peer-to-peer experience sharing for cancer survivors.

With respect to stuff (ie, equipment and consumables) and services, infrastructure is inadequate and most of the available care centres are in urban areas. Palliative care is widely offered as a last resort of care, but it should be initiated at diagnosis.
The availability and affordability of cancer commodities continue to impede access for patients in Kenya. Furthermore, on staffing, Kenya faces a shortage of human resource capacity with the requisite specialisation to manage cancer and palliative care. This shortage prevails across different oncology areas. To bridge the existing human resource gap, the Ministry of Health has been conducting capacity-building activities and mentorship to primary care providers in counties, including coordination of specialist outreach programmes in collaboration with tertiary facilities (eg, Busia Hospice, Busia, Kenya). There is a need to strengthen these programmes and provide incentives such as scholarships to encourage health workers to enrol.

Considering space, systems, and synergies, there are adequate spaces that can be enhanced for palliative care in Kenya. In terms of systems, telehealth via mobile phone use (mHealth) is at an early stage of development for palliative care, but could provide new approaches to help support patients in Kenya.[166] Barriers to mHealth that need to be addressed as this technology is developed include mobile network access, and limited access to expertise and hardware required for mHealth. More investments and research are needed to further develop mHealth, but this technology is an area that could have major impacts given the ubiquity and accelerating growth of mobile phone use in sub-Saharan Africa. Synergies for use of such information communication technologies across the continuum of cancer care could benefit palliative care.

Panel 9: Palliative care in Rwanda

Palliative care is an important component of cancer care in Rwanda because many cases are still diagnosed at advanced stages and thus the focus of the treatment shifts to enhancing quality of life. In 2011, Rwanda's Ministry of Health set a goal of universal access to palliative care by 2020.[167] Previously, palliative care was focused on patients with HIV and AIDS, and an oncology programme with palliative care in Rwanda was non-existent. Patients had to travel to neighbouring countries (eg, Uganda, Kenya, and Tanzania) or India to be diagnosed and receive care. Progress has been made to achieve the goal, but much remains to be done. During World Cancer Day on Feb 4, 2020, the Rwandan Ministry of Health launched the National Cancer Control Plan for the next 5 years with the aim of reducing cancer morbidity and mortality.[168] The document highlighted all strategies in cancer advocacy, prevention, treatment, and palliative care.

When considering the 5S strategy,[159] beginning with staff, Rwanda initiated training of a new cadre of home-based care practitioners to provide palliative care in the home in 2011.[167] However, more training is needed to increase the number of staff competent in palliative care. In considering stuff (ie, equipment and consumables) and services, Rwanda has launched the Rwanda Cancer Centre, a modern radiotherapy cancer centre located in Kigali to decrease the burden of disease through treatment and care interventions. There is also local production of morphine in Rwanda. However, palliative care is not yet available at the health-centre level (including morphine), which means the general population has poor access to those services. Despite efforts from the Government of Rwanda in cancer prevention and control, there are still gaps in ensuring availability and accessibility of these services in the country. To address some of those challenges, the Ministry of Health of Rwanda has signed a memorandum of understanding with international cancer institutes to support areas identified as priorities towards improving access to quality cancer prevention and control in Rwanda.

With respect to space, system, and synergies, Rwanda was the first African country to launch a national palliative care strategic plan, and implementation plan to integrate palliative care services into primary-based health services. Upholding the country's commitment to universal health coverage and as part of a broad range of health-related activities at health facilities, in line with the National Decentralisation Policy, cancer control activities are focusing on integrating palliative care across the Rwandan health-care system (appendix p 17). Palliative care services are integrated into the existing health system, including teaching, referral, provincial, and district hospitals.

Oncology Global Mapping data, some children with cancer in SSA are treated by nurses or medical officers. Most paediatric oncology units in SSA are grossly understaffed and fall far short of the recommended minimum of one paediatric oncologist for every 15–30 new oncology patients per year.[196] Nurses are often not dedicated to paediatric oncology units, but rotate through different departments in hospitals, meaning that they do not acquire the necessary expertise to treat these patients safely and effectively. There is also low access to specialised services. Only four SSA countries offer paediatric oncology medical subspecialist training: South Africa, Tanzania, Uganda, and Ghana. The Francophone African Group Programme offers such training for clinicians from several Francophone SSA countries such as Morocco. As discussed previously, and shown in figure 7, the infrastructure critical to accurate diagnosis and treatment, such as radiotherapy, is also scarce or absent in large parts of the region. Programmes providing either high-quality palliative care or care to long-term survivors are rare, and again hampered by inadequate medications (eg, opiates) or specialists (eg, rehabilitation services).[197] The low availability of chemotherapy is a common problem in many SSA countries[198] and, when available, concerns with drug quality are common. Even in countries that aim to treat childhood cancer, inadequate resources, coupled with obstacles such as ongoing political conflict, contribute to interruptions in supply chains. Some countries in the region import chemotherapeutic agents based on adult formulations, which are often inappropriate for paediatric treatment regimens. Despite the clear evidence that treatment of childhood cancer is both feasible and cost-effective in LMICs[199–201] and specifically in SSA, childhood cancer treatment is still perceived as intolerably costly.

The International Society of Paediatric Oncology Global Mapping project responses indicated that 23 (<50%) of 49 SSA countries have active clinical research programmes. African researchers have raised ethical concerns about international collaborative groups that fund treatment for specific cancers as part of research studies, but do not address systemic drug shortages affecting all patients with cancer. Too often, research agendas are set by outsiders lacking knowledge of local priorities, especially when the funding is from outside. For example, high-intensity treatment protocols have been used in some settings that do not have the necessary infrastructure to provide adequate supportive care, which has on occasion led to an increase in mortality rates rather than the expected decrease.[202–204] For example, an intensive regimen including high-dose methotrexate to treat B-cell non-Hodgkin lymphoma was introduced in Malawi, with the unintended consequence of increased treatment-related mortality, leading to low overall survival.[203]

Underlying many of these factors is an absence of political prioritisation of childhood cancer treatment by governments and health systems. Few SSA countries have NCCPs; even fewer of these plans mention children. Those that do, including Burkina Faso, Ghana, Madagascar, Mauritius, Zimbabwe, and South Africa,[202] represent a small percentage of the total expected burden of children with cancer in Africa.

Since 2018 the reported increased incidence of Burkitt lymphoma in Africa[205] is related to endemic Epstein-Barr virus with *Plasmodium falciparum* as a cofactor.[206] Malaria control programmes could potentially decrease the risk of development of Burkitt lymphoma in this region.[206,207] Epstein-Barr virus is also implicated in the development of nasopharyngeal carcinoma and Hodgkin lymphoma. The high prevalence of HIV increases the incidence of HIV-related malignancies such as non-Hodgkin lymphomas and Kaposi sarcoma.[208] Despite minimal supporting published data, the implementation of antiretroviral programmes and the success of prevention

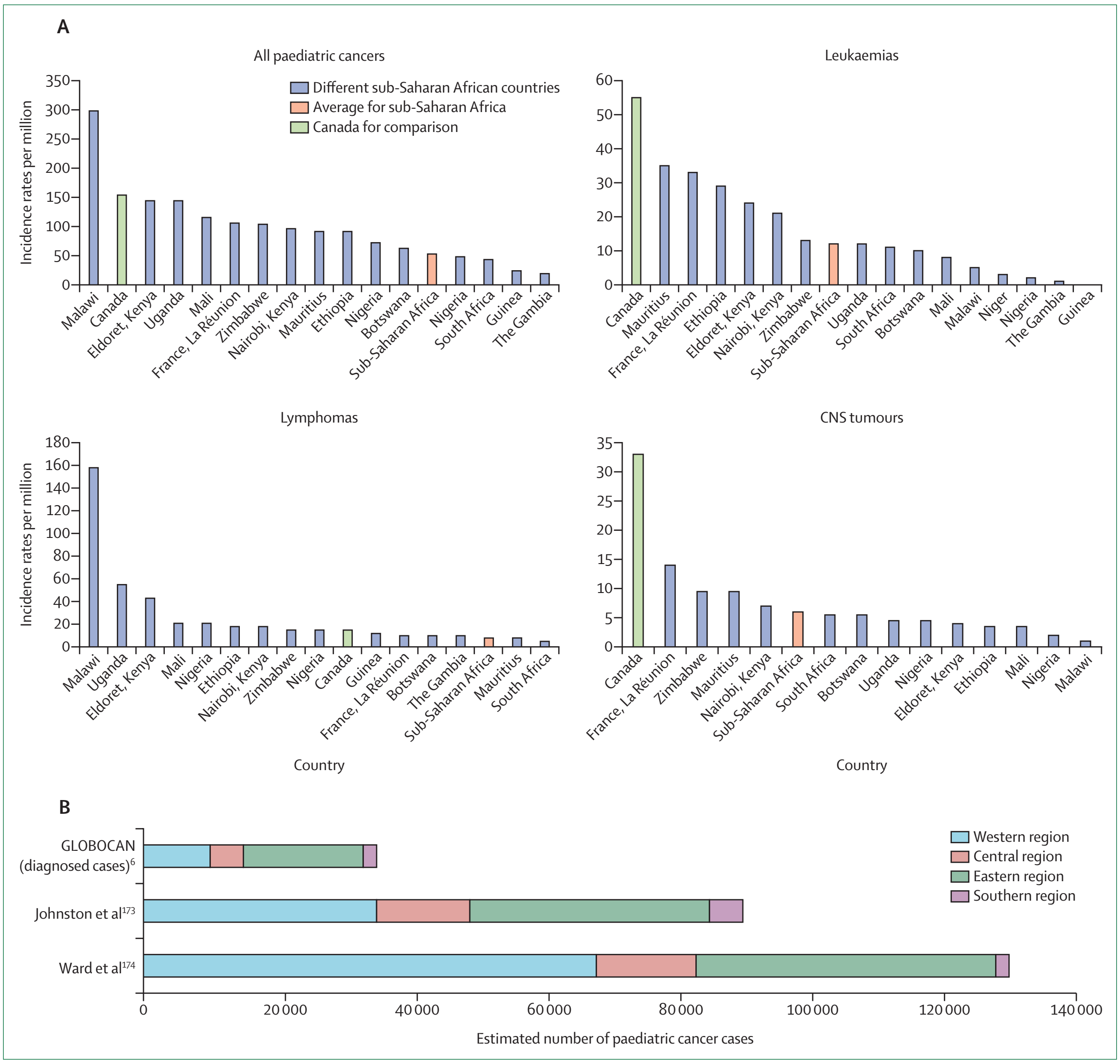


Figure 6: **Estimates of childhood cancers for children 0–14 years of age**

(A) Incidence of paediatric cancers in different countries of sub-Saharan Africa, with Canada as a comparator. (B) Estimates of annual cases of childhood cancer in sub-Saharan Africa, by sub-region.

of mother-to-child HIV transmission programmes could have led to a decrease in the incidence of such malignancies in children.[209]

Enablers of progress

Despite the seemingly overwhelming barriers discussed, there are encouraging signs of progress. Many programmes have successfully addressed some of these challenges in SSA (appendix p 10). Universal health coverage is being increasingly adopted across the continent,[210] leading to strengthened primary health-care systems and hopefully to increased referrals to specialist centres. Several countries, such as Ghana and South Africa, have national childhood cancer plans in draft format. Multiple non-profit organisations run awareness programmes and contribute to decreased treatment abandonment by assisting with transport, accommodation, and psychosocial support. Twinning programmes and collaborations between participants in well-resourced settings and those in SSA have benefited many children, for example the World Child Cancer twinning partnerships involving SSA country institutions in Cameroon, Malawi, Mozambique, and Ghana.[211] Ideally these activities should be led by local teams supported by their governments. Increasingly, collaborations between low-income countries such as the African Paediatric Fellowship Programme and the Francophone African Group Programme fellowship programme are training increasing numbers of physicians in SSA.[212] The model of the International Society of Paediatric Oncology's Africa

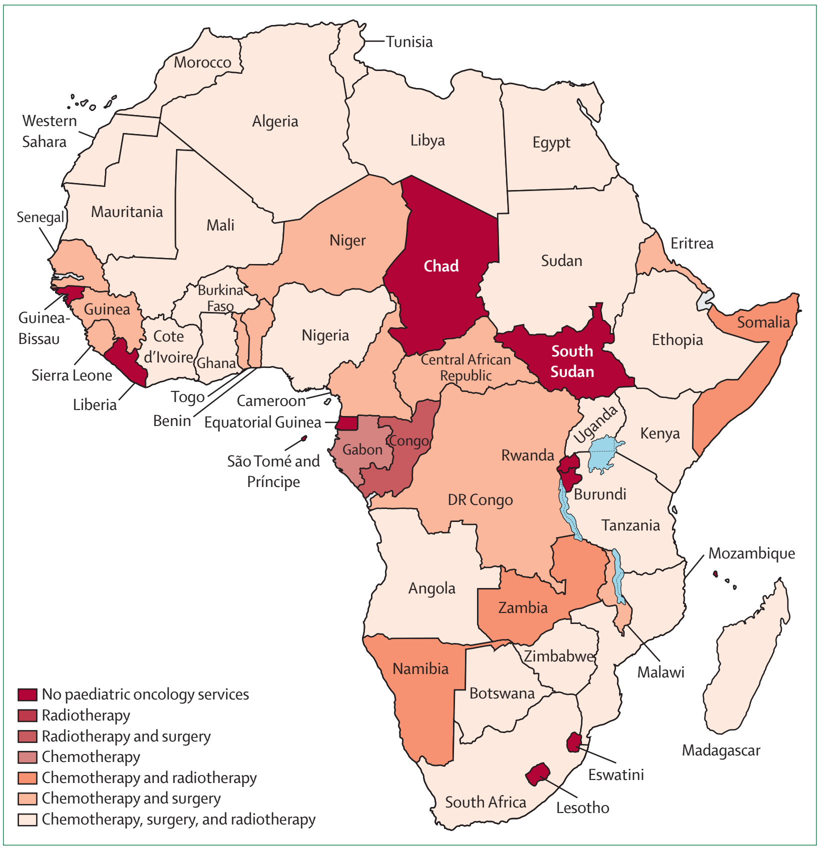


Figure 7: Paediatric oncology services in Africa

Paediatric Oncology in Developing Countries Wilms Tumour Project Group, incorporating start-up funding and mentoring from colleagues in well resourced settings, has led to decreased treatment abandonment, improved survival, and capacitation of local teams.[213] The use of locally adapted treatment regimens is gaining traction: prominent examples include protocols for nephroblastoma in Malawi, Cameroon, and Ghana,[189] and Burkitt lymphoma in Malawi[203] and Cameroon.[182] More intensive harmonised treatment protocols for neuroblastoma[214] and Hodgkin lymphoma have been introduced in upper-middle-income South Africa.[215] Research driven by the Francophone African Group Programme and the South Africa Children's Cancer Study Group is contributing to improved harmonisation of treatment, which might lead to improved survival rates for cancers such as Burkitt lymphoma. The WHO Global Initiative for Childhood Cancer has focused attention initially on selected lower-middle income countries and the collaboration between the International Society of Paediatric Oncology and WHO is expected to contribute to improvements.

Recommendations

The *Lancet Oncology* Commission[200] on sustainable care for children with cancer provides an investment framework justifying a focus on paediatric oncology in LMICs. On the basis of the Commission's recommendations, SSA countries are encouraged to incorporate childhood cancers into essential benefits packages when expanding universal health coverage, including priorities for childhood cancers in NCCPs, eliminating out-of-pocket expenditures for children with cancer, expanding access to effective services for childhood cancers, including childhood cancers when investing in the development of cancer registries, investing in innovation, building upon current collaborations, and creating new ones (appendix p 11). Local African experts and stakeholders must be central to these efforts at all stages, from prioritisation and planning to implementation. Balanced partnerships that leverage both local and international knowledge while retaining loci of control with local stakeholders will ensure sustainable improvements in outcomes for children with cancer across the African continent.

Immediate efforts to improve childhood cancer outcomes in Africa are warranted on both ethical and cost-effective grounds. The WHO Global Initiative on Childhood Cancer aims to achieve 60% survival for childhood cancers globally by 2030.[216] In the context of this initiative, WHO is leading discussions with governments of SSA countries including Ghana, Senegal, and Zambia, to prioritise childhood cancer to improve outcomes for this population. Further initiatives across Africa are planned. Together, these initiatives represent an enabling environment in several SSA countries (eg, Ghana, Senegal, and Zambia) to further develop paediatric oncology services, even during the COVID-19 pandemic.

Section 6: research

The growing cancer crisis in SSA necessitates enhancement of research to enable effective and successful efforts at cancer control, prevention, diagnosis, treatment, and palliation. Compared with other world regions, the amount of cancer research in SSA is low. A review of the National Institutes of Health World report showed that the number of cancer research programmes in North America (13 157) in 2018, was 30-times higher than the corresponding number across SSA (434). Combined, South Africa, Kenya, and Uganda accounted for 49% (211) of cancer research programmes underway in 2018, in SSA.[217] Despite representing 4% of new cancer cases in 2020, the amount of cancer research in SSA falls drastically short compared with higher-income regions.[218] In considering research for SSA, there are two major considerations: the benefit that the research can provide to Africans, and the benefit that the research can provide globally.

Beginning with the benefit to SSA, there is little doubt that increased cancer research will be required to address the large rise in cancer incidence and mortality anticipated in the coming decades.[5,6,53] In addition to the intrinsic value of scientific inquiry, research will provide the basis for societal development. Research results can be translated into drugs, devices, and other technologies that can be optimally applied for the SSA setting. As described in previous sections, although some cancer prevention, screening, or treatment modalities might be readily transferrable to SSA, the implementation of those modalities is unlikely to be optimal without research that addresses the features and needs unique to SSA, as well as population and health system-specific implementation.[6] For example, screening mammography has shown benefits for the early detection of breast cancer, but without access to equipment or trained technologists and clinicians, strategies for breast cancer screening cannot be implemented in SSA in the way they are in high-income countries. These strategies require modification of protocols and substantial investment, for alternative SSA-centric approaches to be devised. Data and knowledge generated by research, when applied, serve as the basis for health policy priorities and resource allocation. In the absence of these data, it is difficult for policy makers to effectively determine how to address their most compelling health problems. As is the case everywhere in the world, the generation of scientific data, technologies, therapeutics, and other interventions drives social and economic growth of a country. The availability of those trained and enabled to conduct research, foster innovation, and science, technology, engineering, and medicine (STEM) brain drain can lead to local and national investment and entrepreneurship that grows economies and infrastructure. Thus, research should be viewed as a necessary part of African development and not a luxury.

In addition to the benefits of research to SSA, research undertaken can also inform our understanding of disease and its management worldwide. Historically, knowledge about cancer that has come from SSA has led to substantial scientific advances with global clinical and public health effects. These include some of the first descriptions of infection in cancer aetiology with Burkitt lymphoma and Epstein-Barr virus, early combination cancer chemotherapies, cancer imaging modalities, and the role of dietary fibre in cancer.[219–222] Many parts of SSA are now in a period of strong economic growth and political stability, which again provides the opportunity to contribute to the world's knowledge of cancer and other diseases. Research in SSA can make major contributions because of the unique disease aetiology and natural history of cancer in the region, and this research must be developed to accrue benefits to Africans and people of African descent worldwide.

Potential solutions: identifying African cancer research topics

African research priorities need to be carefully evaluated and implemented within the context of resource and infrastructure limitations. Prioritisation of research needs in SSA has often been imported from other world regions rather than based on African needs or from input by Africans that prioritises their goals. Thus, future expansion of African cancer research might consider decolonialisation of research activities to prioritise those needs determined by Africans to benefit Africans. Prioritisation of research needs and goals can be accomplished through stakeholder-based needs assessments as well as data-driven evidence (figure 8). Moreover, to better understand and address cancer burden in SSA, there is an urgent need for innovative approaches to address data challenges, including collection, curation, sharing, and big data.

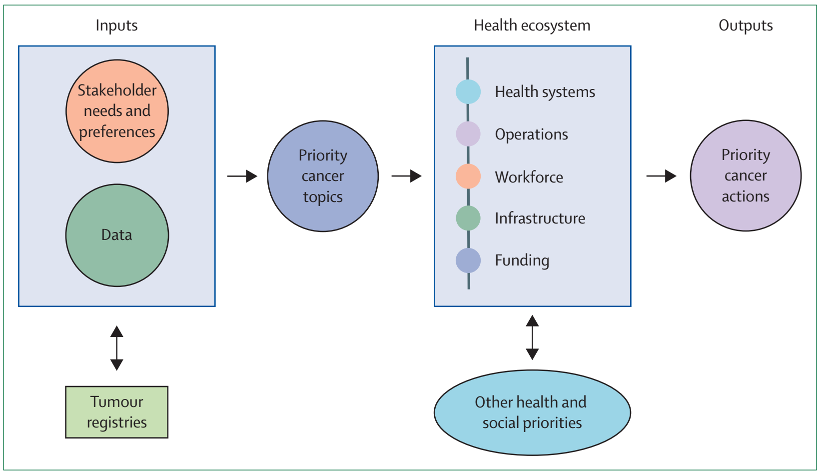


Figure 8: **Determining priority cancer actions to enhance research in Africa**

In cancer prevention, research is required to understand the role of modifiable risk factors for major cancers in SSA. Basic epidemiological research might be required to understand the role of specific risk factors for particular cancers if it is likely that the association differs from that in other populations in which the majority of the association data have been generated. For example, obesity and hormone exposures are strongly associated with postmenopausal breast cancer risk, but a large proportion of SSA breast cancers are found in premenopausal or hormone receptor-negative women, and thus the potentially modifiable risk factors for breast cancer might differ to those reported in White populations.[223] Other risk factors could clearly be as important in SSA as elsewhere, but research might be needed to intervene on these exposures to address the SSA setting specifically. For example, the growth of the tobacco industry and increasing smoking rates in SSA[224] will confer a high risk for lung and other cancers; therefore, tobacco avoidance and smoking cessation are key areas of basic research and implementation science for SSA. It is likely that the approaches needed to reduce smoking exposures might not be easily generalisable from US or European populations to SSA populations. Another important, yet unaddressed, current and future concern for health in SSA is the influence of climate change.[225] Aspects of cancer risk, access to care, comorbidities, and other consequences of a changing climate represent areas of urgent research need. Similarly, underlying germline genetic, biological, and genomic features of some tumours differ in populations of African descent versus those seen in other racial or ethnic groups.[226,227] The unique mutational profiles that are known to exist in Africans could provide an opportunity to better understand the underlying biology of cancer, as well as identify unique germline or tumour molecular profiles associated with prognosis or treatment.

Implementation science for infection-related cancers in SSA requires policy making bodies to create infection control frameworks in the context of environments conducive to health that include clean water, adequate sanitation, nutrition, and alternative sources of income that lead to reduced rates of infection. Important investments in implementation science to achieve HPV vaccination with wide coverage of youth populations and concerted efforts to improve adolescent health are an area of investment that will lead to major reductions in the cancer burden in the region. WHO estimates that nearly 35% of the cancer burden originates from events that occur in adolescence.[228] Creation of an adolescent health platform is thus an urgent need.

In considering cancer treatment, clinical trials are required to develop novel therapeutics and to understand how best to apply existing therapeutics in SSA patients. However, the ability to undertake such research in SSA is limited by the lack of substantial clinical and regulatory infrastructure, particularly for early-phase trials. This situation is reflected in the small number of active cancer interventional studies being undertaken in SSA. Thus, later-phase trials testing the efficacy, toxicity, dosing, and other components of previously approved therapeutics in Africans could be an approach to initiate or strengthen clinical trial infrastructure. For example, the African Consortium for Cancer Clinical Trials of Bioventures for Global Health has developed a systematic readiness evaluation, determining needs and processes for increasing access to cancer diagnostics, medicines, and treatment that can effect treatment itself and the capacity for increasing clinical trials. Similar arguments might be applicable to chemoprevention research. Non-therapeutic interventional studies in behavioural and psycho-oncology, cancer survivorship, and palliative care are also critical areas of research given the extreme burden of many cancer diagnoses in Africans. Patient access to research—especially clinical trials—must also be addressed by identifying pathways for trial access, enabling financial and logistical means to enable clinical trial participation (eg, patient navigators, transportation, and family support to trial participants), and provision of education about the value of cancer research participation. Finally, there is a need for research activities that can address implementation, dissemination, and maximisation of resource use. Thus, research in the domains of health economics, health services, and care delivery represent needs for cancer research in SSA.

Stakeholder-driven prioritisation

Broadly defined stakeholder groups of patients, communities, advocacy groups, health-care providers, health systems, policy makers, ministries, and other groups provide critical feedback about the needs and goals for research in SSA. Almost every SSA country has generated NCCPs that describe the cancer landscape in their countries, define cancer needs, and propose priorities for cancer activities. Some of these plans include resource needs including funding, infrastructure, workforce, and other components needed for implementation of these plans. To complement these plans, numerous systematic evaluations, and reports of local, national, or continental needs assessments have been published that can aid in the prioritisation of actions to address cancer in SSA.[229–231] Stakeholder-based needs assessments have also been undertaken to understand the needs of health-care workers, patients, community members, and others to guide the use of finite cancer research resources. Broad systems perspectives have been proposed,[232,233] but often these evaluations focus on a specific disease area (eg, breast cancer or palliative care) whereas other approaches focus on capacity, advocacy, care access, treatment, clinical trials, cost, health economics, or other specific topics.[234–237] Thus, multiple approaches might be required to evaluate and prioritise research needs. When identifying these priorities, it is important that they are accompanied by success metrics (eg, if the research were conducted, what impact would this have on the population?) and be focused, achievable, translatable, affordable, and sustainable.

An example of a stakeholder-based approach to identifying priority cancer needs was a project undertaken by the International Collaboration on Improving Cancer Outcomes in Low-and Middle-Income Countries–Africa to assess head and neck cancer research needs in SSA.[238] This project involved multisector stakeholders including clinicians, patient advocacy groups, training organisations, higher education institutes, and policy makers across 14 African countries and the UK. The approach used a modified Delphi method that included a survey to identify major unmet cancer research needs in SSA, followed by multiple rounds of discussion with stakeholder voting to identify the highest priority needs. The outputs included recommendations for research regarding reasons for late presentation, improving access to specialist care, and streamlining pathways of investigation and treatment. Following this prioritisation process, a planning conference was held to identify means to develop research to address this question. This consensus process provides one approach to identify needs and pathways for cancer research in SSA.

Data-driven prioritisation

In addition to stakeholder-determined goals, research priorities could be based on data of cancer rates and trends, geographical hotspots, unique or prevalent cancer risk factors, or other features of the cancer burden in SSA. Less than 2% of the African population is estimated to be captured by population-based tumour registries,[239] and much of the data used to estimate cancer risks and trends are based around models that were generated using sparse data.[6] Several active initiatives including those led by IARC[240] and the AFCRN,[241] such as the Global Initiative for Cancer Registry Development, the Global Cancer Observatory, and the AFCRN Regional Hub for cancer registration in sub-Saharan Africa, provide frameworks, protocols, and data to quantify and monitor cancer in Africa and are of value to researchers and policy makers.

There is no comprehensive source that catalogues cancer research being undertaken in SSA, yet cancer research is clearly being undertaken. For example, ClinicalTrials.gov (as of February, 2022) lists 87 291 cancer-related projects worldwide, with 404 (0·5%) in Africa. On the basis of data from the US National Cancer Institute (NCI) of funding among NCI-designated cancer centres for SSA,[112] the most common cancer research areas included early detection, prevention, treatment, and cancer control. The most common project types were research projects (n=86), capacity-building projects (n=69), and screening projects (n=21). The most studied cancer sites were breast (n=43) and cervix (n=20), with 47 studies evaluating multiple cancers. Although these data do not represent data from all international agencies and foundations that support cancer research, they suggest that robust cancer project activities are underway in SSA, but the scope and number of projects should be increased given the magnitude of the cancer burden on the continent.

Current and future anticipated needs for cancer research can be assessed by comparing the increase in new cancer cases (figure 9A) or deaths (figure 9B), the cancers that are predicted to show the largest mortality increases between 2018 and 2040 (figure 9C), and the cancers that are predicted to be responsible for the most cases and deaths in SSA by 2040 (figure 9D). These data suggest that the cancers that might be prioritised for research in SSA include prostate, liver, cervical, breast, and colorectal cancers, and leukaemia (highlighted in red in figure 9). Although many other metrics could be used to define priorities, objective data must be used to understand and predict future cancer rates and risks to set research priorities in SSA.

On the basis of these data and other information, additional research priority setting is clearly needed to address the current and future cancer burden in SSA. Data about the current and anticipated leading cancers (figure 9) and the state of research could inform this process. A pan-African working group comprised of relevant stakeholders could be created to guide these initiatives. Funding bodies (eg, the US National Cancer Institute, Cancer Research UK, and others) could play a major role in guiding this process, as should knowledge from NCCPs where priorities for research have been developed by local or national agencies. African governmental agencies that oversee research and health funding (eg, ministries of health), non-governmental agencies (eg, AORTIC and the African Academy of Sciences), and possibly industry and venture capitalists should be represented. In addition to pan-African guidelines and initiatives, each country or region should consider local needs and capacity when prioritising research activities. Although fundamental research studies (eg, basic science and epidemiology) are an important focus of cancer research, prioritisation could be given to research that can be readily translated into public health and clinical modalities and interventions that will have the greatest effect on the cancer burden in SSA. One potentially high-impact approach to achieving these goals is to integrate the training of early-career cancer researchers into pilot and career development funding that addresses these prioritised research goals.

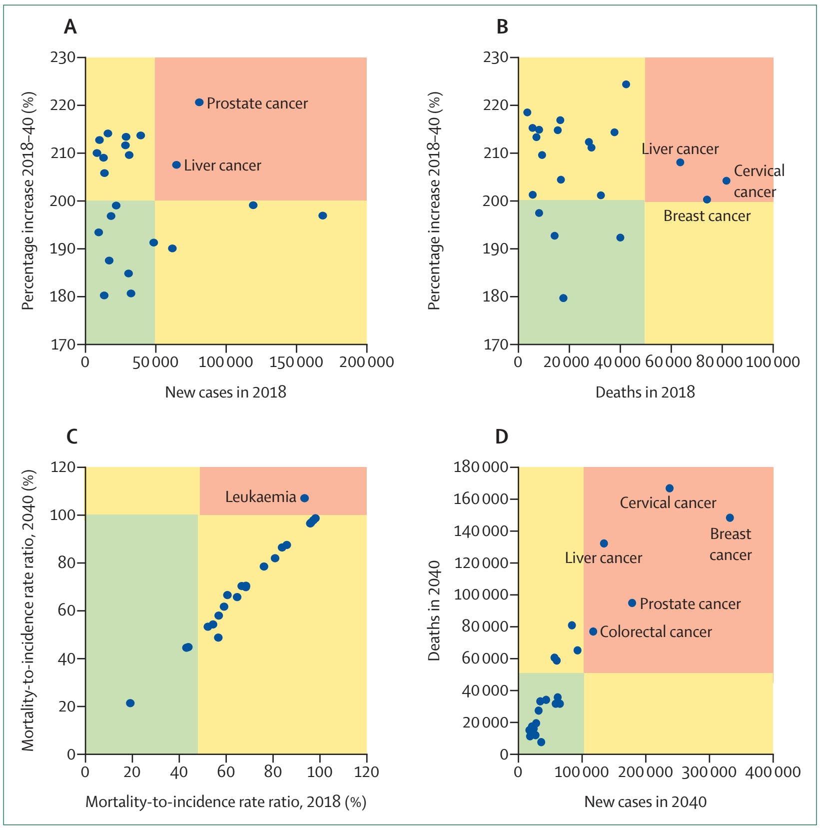


Figure 9: **Incidence and mortality metrics for prioritising cancer needs**
(A) Number of new cases in 2018 and the percentage increase in new cases by cancer site from 2018 to 2040. (B) Number of deaths in 2018 and the percentage increase in deaths by cancer site from 2018 to 2040. (C) Rate ratio of mortality to incidence in 2018 *vs* 2040. (D) Number of new cases in 2040 *vs* number of deaths in 2040. Data from Ferlay and colleagues,[5] Bray and colleagues,[6] and the Global Cancer Observatory. Red shading represents cancers that might be prioritised for research in sub-Saharan Africa, followed by the yellow and green shading. The blue dots represent cancer sites and those of greatest interest are labelled.

For more on the **Global Cancer Observatory** see https://gco.iarc.fr/

Prioritising actions based on the health ecosystem

When considering investments towards cancer research activities, thought should be given to the research

For more on the **African Oesophageal Cancer Consortium** see https://dceg.cancer.gov/research/cancer-types/esophagus/afrecc

For more on the **Men of African Descent and Carcinoma of the Prostate Network** see www.madcapnetwork.org

For more on the **African Research Group in Oncology** see https://www.mskcc.org/hcp-education-training/international/global-cancer-disparities-initiatives

domains, resource and infrastructure investments, regulatory and ethical issues, training, and academic models that are required to create a functional and productive research infrastructure. Substantial variation exists in the capacity of local and national health systems, research infrastructure, and implementation ability. In SSA, the role of cancer research to develop interventions that have clinical or public health impacts needs to be considered in the context of other health needs, including basic health, nutrition, and social services. The development of cancer research should be part of the larger ecosystem of health-related needs that might be implemented incrementally (appendix p 18). Multiple sectors need to work together to define priorities and implement strategies to improve cancer care, diagnosis, and treatment, along with a much closer interaction with local and traditional health-care systems that are used by a large proportion of Africans.

Research resources and infrastructure

For research to be implemented, carefully chosen research resources must be developed. Ideally, these resources will follow from the definition and prioritisation of logistical research needs and the ability to support specific types of research.[242,243] These resource and infrastructure elements might therefore include research laboratory space, equipment, and reagents. Many of these resources require consideration of supply chains (eg, for reagents), service contracts (eg, for equipment), as well as training and certification of operators and technicians. Although these considerations are obvious for wet laboratory settings, the same is also true for computers, databases, and other dry laboratory resources and infrastructure. No laboratory research resource should be invested in without a carefully considered plan for the sustainable operation of this research, including maintenance of equipment and affordable and accessible reagent supply chains.

Cohorts of individuals that might include cancer case series, case-control studies, longitudinal (prospective) cohorts with clinical annotation, and bio-samples represent an important resource for the development of a variety of research studies. The development of epidemiologically well designed studies is crucial for creating opportunities for a wide range of research. Although these studies are extremely expensive to develop and maintain, they should be a goal of population research rather than small convenience samples that do not have a suitable design, statistical power, or the appropriate clinical or biological data to address key cancer research questions. This goal will require substantial investment from funders and SSA institutions, for example using the US National Cancer Institute's Beginning Investigator Grant for Catalytic Research programme. It will also involve enhancing current ethical standards, including data privacy and data sharing standards, for the research to be impactful. Models for such study sets do exist, and often involve consortia focused on a specific tumour site. These models include the African Breast Cancer Study,[244] the African Oesophageal Cancer Consortium, the Men of African Descent and Carcinoma of the Prostate Network, the African Research Group in Oncology, and others. These networks provide an opportunity for partnerships between African researchers and US or European researchers, training and mentoring, and shared resource development.

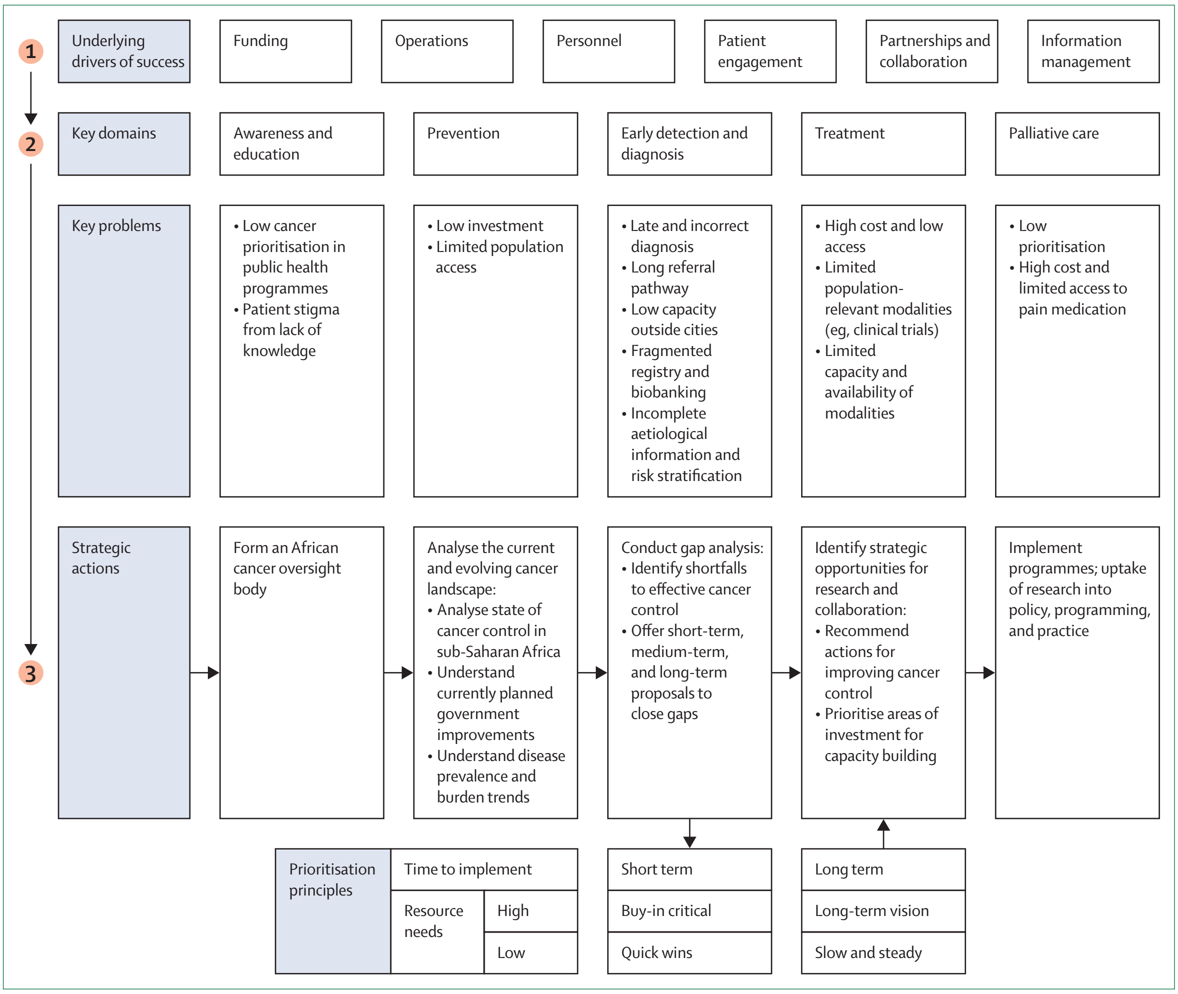
To achieve success from partnerships and networks like these, aetiological and translational research must be complemented by implementation science that addresses social determinants of inequity of access to health care as well as concepts of social justice.[245] Research partnerships must consider the implications of the imposition of European and American values and expectations on the African continent. As has been widely discussed, research partnerships must avoid inequality of participation and benefit of research in SSA, with non-Africans taking data or samples out of Africa, without a consolidated and accountable system of capacity building and development of SSA researchers addressing SSA needs.

Research workforce: career development and academic models

Research cannot be accomplished without adequate workforce and training and can provide opportunity for academic advancement. Thus, advanced degree programmes for research should be expanded in Africa to allow for increased research capacity and to keep talented African researchers on the continent, rather than them having to study outside of SSA to obtain advanced skills. Existing training models in SSA have been largely built on US or European frameworks; creative solutions to research career pathways that might be more amenable to the African setting should be considered. In addition to the training of independent principal investigators, training for research support positions, including laboratory technicians and study staff, should be encouraged. For example, a project management toolkit for study staff has been developed that begins to fill a gap in support of research in SSA.[243] Other supportive training, such as histotechnologist and laboratory technician training, should be advanced to support the needs of the research principal investigator. Institutions in SSA need to do more in establishing and supporting academic tracks, expectations for promotion, and structures that support and reward research activities. A substantial proportion of those who undertake research in SSA are physicians with heavy clinical responsibilities. Hence, there is a need to find models that reward and promote physician scientists to undertake research. These models might require robust mentoring programmes that guide the clinician–scientist and others, but are sometimes difficult to achieve because they require the investment of substantial financial resources, including by SSA governments.

Systems and operations requirements

Cancer research in SSA cannot be undertaken without adequate research administrative structure and appropriate ethical and regulatory oversight.[243] Most SSA institutions have Human Subjects Protection and Institutional Review Boards on the local and national levels that can oversee the informed consent process and compliance with local and national ethical guidelines. However, some of these bodies have not had broad experience with all aspects of cancer research or have not yet set standards for particular aspects of cancer research. Infrequent exposure to some research topics could result in slow responses requiring multiple rounds of questions, which limits research progress. In some cases, SSA institutions could be required to provide additional infrastructure and staffing support, and researchers might need to be prepared to work closely with review boards to set common standards for ethical review, identify efficiencies around the review process, and triage reviews such that exempt or expedited protocols need not undergo the same scrutiny as regular reviews. Additionally, SSA institutions and researchers might require assistance with regulatory aspects of cancer research such as compliance with governmental regulations, the ability to process inter-institutional agreements (eg, materials transfer agreements), or process import–export licences for research data. Essential to the success of research is governance of fiscal compliance and reporting, including obtaining institutional certifications, especially when extramural funding is sought. These might include federal-wide assurances and other commercial and government entity designations, as well as a system for local award management, registration in the National Institutes of Health commons, and compliance with federal conflicts of interest registrations. Additionally, accounting systems that allow for submission of grants, oversight of grant budgets, and receipt of research grant payments are required. Additional funding agencies in Africa and other regions, including foundations, also have further requirements.



Underlying drivers of success	Funding	Operations	Personnel	Patient engagement	Partnerships and collaboration	Information management

Key domains	Awareness and education	Prevention	Early detection and diagnosis	Treatment	Palliative care
Key problems	• Low cancer prioritisation in public health programmes • Patient stigma from lack of knowledge	• Low investment • Limited population access	• Late and incorrect diagnosis • Long referral pathway • Low capacity outside cities • Fragmented registry and biobanking • Incomplete aetiological information and risk stratification	• High cost and low access • Limited population-relevant modalities (eg, clinical trials) • Limited capacity and availability of modalities	• Low prioritisation • High cost and limited access to pain medication
Strategic actions	Form an African cancer oversight body	Analyse the current and evolving cancer landscape: • Analyse state of cancer control in sub-Saharan Africa • Understand currently planned government improvements • Understand disease prevalence and burden trends	Conduct gap analysis: • Identify shortfalls to effective cancer control • Offer short-term, medium-term, and long-term proposals to close gaps	Identify strategic opportunities for research and collaboration: • Recommend actions for improving cancer control • Prioritise areas of investment for capacity building	Implement programmes; uptake of research into policy, programming, and practice

Prioritisation principles	Time to implement		Short term	Long term
	Resource needs	High	Buy-in critical	Long-term vision
		Low	Quick wins	Slow and steady

Figure 10: **Pathways to enhanced cancer research and impact in Africa**
Adapted from Rebbeck and colleagues.[233]

Pathways to enhanced African cancer research

An Afro-centric approach to research in SSA is greatly needed, and has the potential for discovery and translation to address the cancer burden in SSA and globally. On the basis of previous systematic evaluations of cancer research needs and solutions for Africa,[233] we recommend a series of steps to address the impending increase in the cancer burden in SSA through strategic planning and investment in cancer research. A model that can be used to guide strategic planning of activities, to be adapted for the SSA setting by relevant stakeholders, is shown in figure 10.[233] First, an understanding of the underlying drivers of cancer should be identified and understood. Second, the key cancer domains to be addressed, and the most relevant problems and barriers facing these domains, should be identified. Third, strategic actions to address the problems and barriers can be proposed. We endorse the formation of an oversight body comprised of stakeholders representing multiple sectors to undertake these activities. These steps include analysis of capacity gaps, gaining insights on improved network coordination, and identifying opportunities for stakeholder engagement, partnerships, and collaboration. Within this goal is the identification of activities that have long and short times to implementation as well as high and low resource requirements. Success in achieving these goals can result in quick wins (ie, activities that can have an impact in a short timeframe at a low cost); buy-in critical activities (ie, those that can be achieved rapidly, but require resources) that need the support of key stakeholders; slow and steady activities that might be low cost, but will require time to achieve; and long-term vision strategies that can have major effects, but require large investment and will take a long time to achieve. Finally, implementation of the prioritised work might require formation of a pan-African cancer research oversight and funding organisation that can serve pan-African research activities. Using adaptations of this framework and others,[229] strategic opportunities can be identified for which implementation can be achieved, impactful projects can be funded, sustainable research capacity can be developed, and cancer researchers in Africa can have meaningful and rewarding careers.

Panel 10: Components of success in cancer research for sub-Saharan Africa

- Success metrics: tie goals to finite, achievable endpoints and a realistic timeline that are relevant to goals in sub-Saharan Africa (SSA); these might differ from traditional models of success based on outcomes needed in high-income countries
- Institutional buy-in: require co-funding by a local institution; provide incentives to get the institutions on board; foster an academic environment conducive to research
- Governance: require active involvement from key stakeholders, including finance and regulatory personnel in addition to decision makers
- Leverage existing resources: identify existing resources and infrastructure to enhance before building de-novo infrastructures
- Academic environment: train, recruit, retain, and support SSA research leaders; provide academic ladders that are institutionally supported and provide a clear pathway to success for researchers
- Supply chain: negotiate access to reagents, supplies, service contracts, and other resources needed for sustainable research activities
- Staffing continuity: guarantee positions for funded and trained individuals
- Absorptive capacity: avoid funding bottlenecks by providing support in stages and over a longer period so that the system has the time to build an appropriate workforce and infrastructure
- Equitable collaborative research: in the face of the power imbalance, there is a need to empower SSA scientists and institutions to become leaders in research and to actively participate in and lead the framing and prioritising of the research agenda in SSA; there is an opportunity to address some historical injustices; meaningful and sustained linkages between researchers, clinicians, institutions, and policy makers must be developed
- Decolonise research in SSA: there is a need to challenge the Eurocentric approaches and methods that undermine local knowledge, experiences, and solutions
- Consider the local health ecosystem: SSA health ecosystems are extremely heterogeneous; planning for strategic research development must account for local data and consider local stakeholder input including research on herbal or medicinal plants, which are part of the SSA health-care system
- Balance care and research: given the unique cancer burden in SSA as well as the existing structures of prevention, screening, and treatment, fundamental research that has near-term potential for public health and clinical impact should be prioritised

One approach to promoting the development, teaching, and training of research and researchers is to create centres of excellence. Examples include the Uganda Cancer Institute in Kampala and the Butaro Cancer Centre in Rwanda, which provide a wide range of diagnostic and treatment services for cancer, including chemotherapy, surgery, pathology, counselling, and palliative care. The Uganda Cancer Institute was funded in collaboration with the Fred Hutchinson Cancer Research Centre (Seattle, WA, USA); the Butaro Centre is supported by Partners in Health (Butaro, Rwanda) and the Dana-Farber Cancer Institute (Boston, MA, USA) in collaboration with the Rwandan Ministry of Health. These centres serve a referral population who come from a large geographical area. Both centres are resources for research and training in cancer care and are examples of what can be done, even within the limitations imposed on Africa due to economic, social, and many other challenges.

To achieve success in these activities, the domains shown in panel 10 should be considered in the development of research capacity.[230] These include success metrics, institutional buy-in, governance, leveraging existing resources, academic environment, supply chains, staffing continuity, absorptive capacity, equitable collaborative research, research that is driven by local needs and capacity rather than led from outside SSA, and balancing care and research. By strategic planning and implementation of these or similar processes and inclusion of key stakeholders from various sectors representing SSA perspectives, the knowledge needed to address the cancer burden in SSA can be generated by Africans capable of producing this research with success.

Summary

We present principles whereby institutions, including SSA academic and medical centres as well as ministries of health and education, could enhance cancer research activities in SSA. We have identified cancers of elevated incidence and mortality, or that are increasing over time. Individual countries or regions could replicate these summaries to identify their own data-driven priority cancers. Since countries in SSA represent extremely heterogeneous health ecosystems, undertaking thoughtful stakeholder engagement when engaging in strategic planning for research is important. We also present a framework that can be used by governments and non-governmental organisations to plan strategically for cancer research enhancement in SSA.

Section 7: oncology workforce

In the previous sections of this Commission, the need for oncology workforce training across the cancer control continuum has been consistently highlighted. The oncology workforce consists of people who possess competencies and have occupations that enhance the health of their communities through the delivery of cancer control services. The oncology workforce can be divided into two groups—those who deliver direct cancer prevention or management services called health service providers and those whose competencies are related to health management or supportive services. The oncology workforce in SSA is experiencing shortages and stress due to the increasing and shifting disease burden from communicable diseases towards NCDs, limited training opportunities, maldistribution of populations, inefficiencies, weak enabling policies, and inability to coordinate with private sector providers.[214,246–249] Situations like these result in labour market failures, with oncology workers seeking opportunities and job security in lucrative health labour markets even in countries with large numbers of unemployed health professionals. Poverty, imperfect private labour markets, inadequate public funds, bureaucratic red tape, and political interference exacerbate shortages amid underutilised talent. The HIV and AIDS epidemic and surging cancer incidence in SSA has contributed to huge work burdens, deaths in the workforce, and the health sector being insufficient and unable to manage the growing cancer burden.[250–252] As a consequence, the oncology workforce crisis in SSA is characterised by severe personnel shortages, inappropriate skill mixes, inefficiencies, and gaps in service coverage. There is an urgent need to improve the oncologist-to-patient ratio in the region.

According to WHO estimates, globally there are currently 57 countries with critical workforce shortages equivalent to a global deficit of 2·4 million doctors, nurses, and midwives.[253] The proportional shortfalls are greatest in SSA, and are attributable to poor remuneration, insufficient opportunities to obtain specialised oncology training on the African continent, and the emigration of the few trained personnel to high-income countries where the remuneration and conditions of service are much better. A survey[140] of African oncologists within the AORTIC network shows that they have a substantially higher clinical workload and lower job satisfaction than oncologists elsewhere in the world. In many SSA countries, the competencies of health-care professionals are not properly optimised, distributed, or well matched to the local profile of health needs. Many workers face daunting working environments, poverty-level wages, unsupportive management, insufficient social recognition, and weak career opportunities and development. Almost all SSA countries suffer from population maldistribution characterised by urban concentration and rural deficits. Compared with other regions, such as Europe, expenditure on health and the workforce are inadequate to strengthen workforce capacity and provide adequate coverage of services. Although the WHO region of the Americas, with 10% of the global burden of disease, has 37% of the world's health workers and spends more than 50% of the world's health financing, the WHO African region, which has 24% of the global disease burden, has only 3% of health workers and spends less than 1% of world health expenditure.[246,247,254] Baseline shortages, rapidly increasing cancer burden, and unfavourable attrition rates place Africa at the epicentre of the global health workforce crisis. Demand for oncology services will escalate substantially in all SSA countries over the coming years, since the number of patients with cancer is expected to double by 2040. Without massively increasing strategic investments, implementing policy levers, and strengthening training in SSA, governments will be unable to meet the targets in the 2030 Sustainable Development Goals, including a failure to achieve universal health coverage or reduce premature cancer mortality. To develop the agility to respond to oncology crises, to meet current gaps, and to anticipate the future, the workforce goal should be simple—to get the right number of workers with the right skills, in the right place doing the right things.

Addressing the oncology workforce crisis in SSA: what, how, who, and when

A systematic approach to workforce optimisation in SSA is needed, focusing on key policy levers to shape the labour market, and contextualise to a national context. This approach begins with an in-depth review of published and unpublished data on the current state of the oncology workforce in SSA, followed by defining core competencies; addressing migration, maldistribution, and inefficiencies; and optimising the current workforce while scaling up capacity. As highlighted in a previous section, multidisciplinary care is needed, eg, via multidisciplinary tumour boards, to ensure quality and reduce inefficiencies by improving productivity and performance. A multidisciplinary tumour board in

Mozambique[255] was associated with a 53% mortality decrease among patients with early-stage breast cancer and was found to be cost-effective. Choosing Wisely Africa convened a task force through AORTIC to identify ten practice recommendations for improving value-based quality oncology care in Africa, which included, "do not decide the treatment of potentially curable cancers without input from a multidisciplinary oncology team".[124] Their input can be during physical meetings whenever possible or virtually. The current review was limited to personnel engaged in paid activities and excluded home-based, traditional healers, and self-care services, although these activities are important contributions to overall service provision and are crucial to the functioning of overwhelmed fragile health systems. The key findings were that, in SSA, there is a major shortage of the health workforce in general and oncology teams across the cancer continuum.[140]

Pathology workforce

Lack of diagnostic information leads to erroneous or empiric treatment, leading to patient harm, inferior outcomes, and inefficient resource use. Developing a competent pathology workforce currently faces challenges in SSA related to inadequate recruitment, retention, teaching faculty, credentialing, and uniformity of training standards.[231,256–258] These challenges are compounded by low public sector investment, particularly in the health workforce and diagnostic equipment, contributing to high attrition rates or exodus to the private sector.

SSA has only one pathologist per 1 million population compared to one per 8000 in the UK and one per 20 000 in the USA. The distribution of pathologists per population in SSA ranges from 1:224 897 in South Africa to 1:1 072 565 in Nigeria, 1:2 236 000 in Rwanda, 1:2 187 545 in Tanzania, and 1:3 174 000 in Mozambique.[256,257] Furthermore, diagnostic resources are inequitably distributed in the public sector, centred mainly in urban settings. With the current rate of attrition and low number of new graduates, it will take more than 400 years for SSA to catch up with high-income countries.

There are currently 27 postgraduate residency training programmes in pathology in SSA.[249,257] However, exposure of trainees to adequate specimen numbers, a suitable variety of samples and cancer types, and access to ancillary testing are required for a well-rounded high-quality combined anatomic pathology and clinical pathology training programme, which might be a challenge for some of the training programmes in SSA. Short-term workforce solutions in pathology can include establishment and support of colleges of pathology in regions where no formal training programmes in anatomic pathology and clinical pathology exist and supporting the establishment of pathology post-graduate programmes with partners, such as other African institutions or institutions outside of Africa. Low-income country exchanges of post-graduate residents in anatomic pathology and clinical pathology would permit exposure of fellows to a wide variety of cancer samples, ancillary techniques, and cancer biomarker testing. Because of the scarcity of the workforce in anatomic pathology, pathologists are often left to practice unsupported, resulting in diagnostic errors, especially for complex cancer specimen types. Dynamic telepathology[259–262] could be a potential platform that could support linkage of pathologists between and within countries and continents. Role delegation through training technologists to do selected tasks including resection and analysis of small biopsies can also help in spreading the workforce to serve more areas. The inclusion of artificial intelligence using innovative deep machine learning diagnostic algorithms could in the future help to augment the scarce pathology workforce on the continent.

In-person and virtual training, and mentorship programmes, are potential solutions that have shown great promise.[249,259,263,264] Medium-term and long-term planning towards an accredited oncopathology fellowship that is informed by local needs and determined after mapping current competencies could help to build capacity towards a specialist cancer-focused anatomic pathology and clinical pathology workforce able to support cancer diagnostics. Additional strategic investment in subspecialty training in molecular pathology, genomics, data science, and computational and digital pathology could enable future pathologists practising in Africa to offer precision diagnostics to inform best practice for optimal cancer care. Strengths, weaknesses, opportunities, and threats for the pathology workforce to support cancer diagnosis are highlighted in the appendix (p 12).

Clinical oncology workforce

A 2018 review[245] of the global clinical oncology workforce found that in 26 African countries, a clinical oncologist would provide care for more than 500 patients, and in extreme scenarios more than 1000 patients in about 25 African countries. SSA countries such as Burundi, Central African Republic, Togo, and Burkina Faso, among others, reportedly have no trained clinical oncologists at all. An insufficient number of oncology providers can result in substantial cancer health inequities between and within countries. In a global survey of 93 countries, eight countries (9%) had no clinical oncologist available to provide care for patients with cancer. In 22 countries (24%), a clinical oncologist would provide care for less than 150 patients with a new diagnosis of cancer, whereas in 39 countries (42%), a clinical oncologist would provide care for more than 500 patients with cancer. In 27 countries (29%), a clinical oncologist would provide care for more than 1000 incident cancers, of which 25 were in Africa, two were in Asia, and none were in Europe or the Americas. Countries in SSA have an average of 6·4 clinical oncologists (range 0–40), with an average ratio of new cancer cases per clinical oncologist of 3743 (range 236–15 000).[245] In a 2019 review[140] the proportion of oncologists seeing more than 500 patients per year was 31% (11 of 36) in African countries compared with 12% (129 of 1079) in other countries. The median number of patients seen in a full day of clinic in surveyed African countries was 25; 19% of oncologists (7 of 36) saw more than 40 patients per day compared with 9% (102 of 1079) in other countries.

Surgical oncology workforce

Around 80% of new cancer cases worldwide require surgical intervention at some point in their management, but substantial variation exists in the availability, accessibility, affordability, and quality of surgeons managing oncological diseases.[130] The WHO African region has the lowest physician-to-inhabitant and surgeon-to-inhabitant ratios.[265] Compared to the WHO European region with a median number of 848 surgical providers (eg, surgeons, anaesthesiologists, and obstetricians) per 10 000 patients with cancer (range 191–2854), the WHO African region has a median of only 52 surgical providers per 10 000 patients with cancer (range 11–889).[266,267] Density of surgical providers correlates with patient outcomes, including mortality.[131,268]

Surgical cancer care is a low-cost, high-impact cancer treatment strategy, offering value for money and rapid implementation and scale-up capacity, which should be prioritised in all settings, particularly those with limited budget allocation available to cancer programmes. Fundamentally, increasing cancer care capacity towards the achievement of universal health coverage mandates that the performance, quality, and impact of the surgical workforce is optimised through evidence-informed policies and sustainable financing.[269] Similar to other occupations in oncology, the existing labour market in SSA is insufficient to manage the disease burden.

To address gaps in training and the inefficiency of the existing surgical oncology workforce, targeted solutions are needed in the short term, while incremental investments are needed in local education and training for long-term sustainability. Although the practice activities of surgical oncology are generally consistent across cancer types and stage of disease (ie, preoperative evaluation, perioperative care, and postoperative management), the complexity and intensity of the accompanying competencies differ. This recognition informs workforce planning. Surgeons generally do not require fellowship-level surgical oncology training to provide adequate basic cancer care. This fact is consistent with the reality that the majority of cancer surgery worldwide, including in SSA, is performed by general surgeons.[265] General surgeons providing cancer care do require fundamental education in the care of oncological disease, training in how to perform common cancer operations, and knowledge of appropriate referral patterns for patients who are beyond their scope of practice to avoid the performance of technically inadequate surgical procedures.[270] These basic oncology competencies, tailored to what the trainee will actually practice, need to be integrated into general surgery training programmes, to meet the cancer surgical needs in most settings. A small study in Mozambique examined residents' knowledge in various domains of cancer care and found a mean percent correct test score of 37%,[271] with the lowest scores achieved in the surgical oncology subsection. Education should be tailored to the local context, focusing on the most prevalent cancers in the region (eg, breast cancer in SSA as a whole).

More complex surgical oncological care can require additional pre-service training or education. This concept has been validated in high-income countries in which specialty trained providers have superior outcomes.[272] Surgical oncology fellowships are often necessary to train specialty providers in complex surgical oncology care that is beyond the scope of general surgery residency. Fellowship training can also offer other important competencies related to multi-disciplinary care and research. Yet, in SSA, there are substantial deficits in specialty trained surgical oncologists able to manage the most complex cases. The presence of surgical oncology fellowship programmes inversely correlates to a country's income level.[132,273] The College of Surgeons of East, Central, and Southern Africa and the West Africa College of Surgeons have fostered postgraduate surgical education and training with the goal of enhancing surgical services in SSA. There are other examples of initiatives to enhance oncology surgical skills in SSA (appendix p 13).

Access to cancer surgery is further constrained by geographical barriers. Most surgical providers in SSA are concentrated in urban centres. For example, in Ethiopia,[274] half of the graduates from surgical training programmes who remain in the country are employed in the capital city, Addis Ababa, where only 4% of the population resides. More than 80% of the population of Ethiopia lives in rural areas, which remain largely underserved with an average of one surgeon per million inhabitants.[274] There are also differences in surgical availability between public and private institutions in many countries. An analysis of surgical resources in South Africa found striking disparities in personnel and hospital resources between the public and private sector, with resources in the private sector similar to those available in high-income countries.[275] Financial and practice incentives can be used to encourage practice outside of major metropolitan areas and serving in the public sector. Moving toward rural hospital-based training programmes or incentivising trained surgeons to practise in underserved areas can help to address this issue.

Improved working conditions, adequate compensation, and appropriate protections from occupational exposure to infectious diseases can also help maintain the workforce and attract valuable providers to remain or return to the surgical workforce in their home country.[276,277] Policies to support participation of key groups, such as women, should be developed as women are underrepresented in surgery in SSA, with low enrolment and high attrition rates during training. The Pan African Women's Association of Surgeons links female surgeons to provide support and mentorship in an effort to address this disparity and increase the number of women surgeons in SSA, which would help strengthen the surgical workforce overall. Other initiatives have also been helpful including: the College of Surgeons of East, Central, and Southern Africa, the Society of Surgical Oncology and the European Society of Surgical Oncology global curriculum, the Global Online Fellowship training programme, the Paediatric Oncology Experimental Therapeutics Investigators' Consortium, Pan African Women's Association of Surgeons, Project ECHO (Extension for Community Healthcare Outcomes), the Global Surgical Training Challenge, Choosing Wisely, AORTIC, and the Global Oncology University,[263] among others.

To optimise the workforce, role delegation can also be explored, and the skill mix composition improved, which includes building capacity in multidisciplinary care. A short-term strategy to address deficits in available providers is to explore role delegation or supportive supervision to train non-physician providers to do basic procedures. This strategy can also extend the ability of a single surgeon to provide care, either directly or indirectly, to a larger number of patients. An appropriate skill mix will ensure access to quality, safe, and effective cancer surgical care. Safe surgery requires not only the person performing the operation, but also an anaesthesiologist (or equivalent), nurses, and a multidisciplinary team of clinical and non-clinical personnel who collaborate to provide preoperative, intraoperative, and postoperative care.[13] Strategies to address these issues are multifaceted and include basic training in cancer surgery for general surgeons, improving availability of specialised surgical oncology training through fellowship programmes and international exchanges, distribution of providers to underserved countries and regions, and using innovative solutions and technology to fill gaps.

Radiation oncology workforce

The workforce in radiation oncology is multidisciplinary in nature. It requires that there be radiation oncologists and clinical oncologists, medical physicists, radiation therapists, and oncology nurses, forming the core expertise to run a radiotherapy facility. Knowledge and skills must be constantly updated through continuous medical education, and particularly when new radiotherapy technology and treatment innovations are introduced. With the rapid development of radiotherapy in recent years, the education and training of radiotherapy professionals has become of paramount importance, not only to provide access to these services, but also to ensure safe and effective treatment at all times.

The radiation oncology workforce, however, remains heavily depleted as evidenced by the paucity of radiotherapy services on the continent. The shortage of radiotherapy professionals is seen as one of the most critical barriers to increasing access to cancer services in SSA. The IAEA, through its human health programme, provides a formula to estimate the medical workforce demand of the countries. It has been established that one radiation oncologist should generally treat 200–250 patients per year, and one medical physicist should generally treat 400 patients annually. Taking these numbers into consideration, there is an estimated shortage of more than 15 000 radiation oncologists and more than 11 000 medical physicists worldwide.[278] Africa is estimated to require a 211% increment in the radiotherapy workforce to enable equitable access to radiotherapy.[279] Only 6% of the global medical physics workforce resides in Africa and Latin America[280] Eight countries in Africa have more than 20 medical physicists, but the majority only have one or two. Similar disparities are found in the surgical workforce and radiation and clinical oncologists on the continent, with the vast majority working in north African countries and South Africa.[281]

Training of professionals in the setting they will be practising in when they have qualified has several benefits. Planning and investing in infrastructure for training could yield immediate improvements in quality of and access to patient management facilities since standards suitable for training are being met. The trainees are taught to manage the most common cancers in their day-to-day practice, thus developing relevant expertise to handle common and specific national health needs. Following the infrastructural set-up, there are cost savings in local training compared with supporting a fellow training in another country. In-country training also has the benefit of reducing the flight of skills out of the country, provided care is taken to put in place reasonable retention incentives to remain. Although in the past decade or so there have been more training programmes initiated in centres in SSA, most established training centres are still located in northern Africa and South Africa. The important dynamics governing this distribution are the availability of infrastructure and trainers. Training trainers to establish training programmes where they are needed is therefore important.

The aim of curriculum development needs to be anchored in an evidence-based approach that, in the first instance, addresses provision of radiotherapy services that cover the whole population and is in keeping with the resources of the particular country where the training takes place. NCCPs should enable the mapping out of needs for emphasis in the development of training curricula that would grow with the evolution of the plans themselves. The shortage of trainers for health education in Africa is ubiquitous. There is no unified accreditation system as exists on other continents, which are usually based on an international standard of expectations.

Opportunity for innovation in curriculum development is abundant and must be encouraged to close gaps in learning and customise education and training to the local health-care needs. Many organisations within and outside of the continent assist with radiotherapy education, training programmes, and quality assurance in Africa. Although these resources are in existence, they are not readily packaged as a single presentation. WHO has initiated robust self-sustaining training programmes in Africa and developed workforce optimisation tools that have had regional impacts, such as OpenWHO. Such models need to be encouraged and sustained.[253] Another organisation that has been providing training resources in the field is the IAEA, which has made publications available online at no cost.[282]

Nursing oncology workforce

Although oncology nursing is an established field of nursing,[283] it is still underdeveloped in Africa[282,284,285] because specialist education and training is primarily based on demand and supply influenced by factors such as competing health priorities, disease patterns, and the availability of resources. Similar to the rest of the world, nurses in Africa form the majority of the health-care workforce[284,285] and more than 60% are professional nurses who have completed a 3-year nursing training programme,[253] with little or no oncology in the curriculum.[257,286] As opportunities for specialist education and training are scarce, the majority of nurses have to learn the complexities of cancer and cancer nursing on the job.[254,287]

Little is known about the oncology workforce in Africa; however, Boyle and colleagues[281] found that in 2015, Africa had 287 radiation oncology nurses, the majority in north Africa, with the number of radiation oncology nurses in the rest of Africa unknown. South Africa's oncology nursing programmes cover the cancer continuum and are considered to be the most robust in Africa because they are offered at universities.[284] These learning programmes lead to registration as a specialist nurse with the South African Nursing Council, and there are currently 655 nurses on this register.[288] Kenya also has specialist cancer nursing programmes[284] and, according to a recent survey in 2019, countries such as Ghana, Nigeria, Zambia, Tanzania, Zimbabwe, and Rwanda also offer such programmes, whereas Botswana and Malawi are developing curricula and will soon offer their newly developed learning programmes.[285,289] Staffing norms, which would allow quality and safe patient care, suggest that five registered nurses are needed for every 17–20 patients with cancer admitted to inpatient units,[289] a ratio that Africa is unable to meet.

A competency-based framework for nursing care in oncology is important for cancer control because nurses provide care throughout the cancer care continuum.[214,253] Specialist nurses play an important role in increasing access to primary health care in rural communities.[253] Furthermore, these nurses can educate communities about healthy lifestyles, assess and refer patients with cancer-related symptoms,[290] and assist with the management of patients with cancer reporting with minor ailments who are currently neglected at the primary health-care level.[291] To improve cancer treatment and care in Africa, it is necessary to educate and train oncology nurses. Untrained nurses feel inadequately prepared and are aware that they cannot deliver optimal nursing care to patients with cancer.[285] Research has shown that retention rates of specialist nurses are high, and they share their knowledge with others and thus help to improve nursing practices.[292]

The High-Level Commission on Health Employment and Economic Growth recently published a report entitled *Working for health and growth: investing in the health workforce*.[293] The commission found that investments in the health workforce generates dividends across the Sustainable Development Goal agenda, not only for health, but also for global security, education, gender equality, stable and rewarding jobs, and inclusive economic growth. These benefits provide greater impetus for investing in oncology workforce training in SSA. Recommendations for the SSA oncology workforce are highlighted in panel 11.

Summary

The shortage of the oncology workforce in SSA is likely to determine the pace of scaling up cancer care in SSA because any investment made in cancer care without comprehensively addressing shortfalls in the workforce will fail. Because of the historical and social economic differences between SSA countries, the shortage of the oncology workforce requires critical analysis of the factors contributing to the shortage and stakeholder's engagement in both problem diagnosis and problem solving. A complete culture change in how SSA assesses the oncology workforce's needs and defines core competencies will be required. A one size fits all solution or blueprint will not work and if deliberate efforts to address the current oncology workforce crisis are not made, the consequences will be dreadful. National leadership and global solidarity are essential to solve the workforce crisis by implementing actions recommended.

Section 8: health systems including universal health coverage, cost implications, and private provisions

Although refined to manage the burden of infectious diseases, the health-care systems in most SSA countries were originally neither designed nor equipped to manage cancers and other chronic and complex conditions, which require longitudinal and multidisciplinary care. Cancer outcomes in SSA lag behind other regions despite African countries' financial commitments—albeit limited—to address NCDs and general health system strengthening. Africa faces numerous competing challenges concerning

Panel 11: Recommendations for the oncology workforce for sub-Saharan Africa

Sub-Saharan African countries should develop short-term, medium-term, and long-term action plans focusing on solving the factors revealed to lead to oncology workforce shortages

Policy issues

- Revise health policies to address low workforce motivation, migration, brain drain, illness and death of health professionals, inequities, health injustices, and inefficiencies in the health systems
- Formulate policies to guide oncology education, training, and practice
- Assess workforce needs and define core competencies required
- Address migration maldistribution and inefficiencies
- Optimise the workforce and promote quality
- Exploit alternative service delivery mechanisms (community-based, syndromic approaches) to reduce the workload of health personnel
- Recognise the importance of aligning health sector, civil service, and macro-economic policies and their objectives to improve the oncology workforce performance
- Recognise, regulate, and license oncology disciplines
- Increase availability of reliable affordable internet and bandwidth

Attrition rates and brain drain

- Offer internally competitive wages and benefit packages to retain highly trained staff; this approach includes increasing compensation so that workers receive a living wage, and do not have to seek outside employment or under-the-table payments for services to survive
- Invest in training that is specifically oriented to the needs of national markets
- Improve the non-monetary incentive frameworks faced by health personnel (eg, continuous training and mentorship, supervision, and appropriate equipment) to improve motivation and thus the productivity and quality of the health workforce
- Engage and show appreciation of the contribution of oncology professionals in the diaspora
- Make deliberate efforts to turn brain drain to brain circulation

Oncology staff training and recruitment

- Increase oncology training capacity in higher-learning institutions by expanding faculty and student numbers, and providing the funds required for expansion to match their current needs
- Take advantage of information communication technology for training the oncology workforce, for example scale up the use of the virtual Global Oncology University and Bioventures Virtual Global Initiative
- Embed oncology training in existing programmes such as medicine or nursing
- Expose high school and university students to oncology through outreach programmes
- Market job opportunities and incentives to raise interest in training in oncology

Oncology staff retention

- Increase current poverty level salaries to a level that covers living costs
- Improve working environments by ensuring laboratory, treatment, and research facilities that meet international standards are available
- Available funded opportunities for further training
- Develop retirement plans with options to continue using retired staff
- Recognise added certificates for continuing medical education and reward staff financially

governance—such as conflict, poverty, unemployment, food security, climate change, inequity, and industrialisation—which makes prioritising health and cancer difficult. Government commitments to health have been made at several global and regional fora—such as the 2001 Abuja Declaration—yet the follow-through on those promises has fallen short.[294] Consequently, health improvement projects and associated outcomes tend to correlate with external donor support. The priorities of external donors are often pursued since they are providing the funding, instead of priorities of the recipient SSA countries. Most health systems in SSA are chronically underfunded, manifesting as health centres in need of repairs or upgrades, shortages of medical equipment, an insufficient health workforce, and inconsistent supply of medicines. Due to the lack of universal health coverage, most SSA countries experience high rates of out-of-pocket expenditure on health.[295] The absence of financing mechanisms to cover patients' catastrophic health-care costs results in altered and delayed care-seeking behaviour. Even in instances where treatments are provided at no cost, patients in SSA are often burdened with the costs associated with diagnosis, including travel to and housing near the treatment centre, loss of wages while undergoing treatments, and childcare costs. The poorly funded health system and altered care-seeking behaviour of patients impede the health systems' ability to detect and diagnose cancers at early stages, contributing to the late diagnosis of cancers and poor treatment outcomes expected in SSA.[296]

Health-care systems are built around seven main pillars: health-care financing, health workforce, access to essential medicines, information management systems, service delivery, leadership and governance, and essential health research. The gaps within these pillars make it nearly impossible to tackle the growing epidemic of cancer in SSA effectively.[297,298] The President's Emergency Plan for AIDS Relief has long supported the augmentation of government efforts in improving health systems in SSA. The broader impact of the programme and the transition

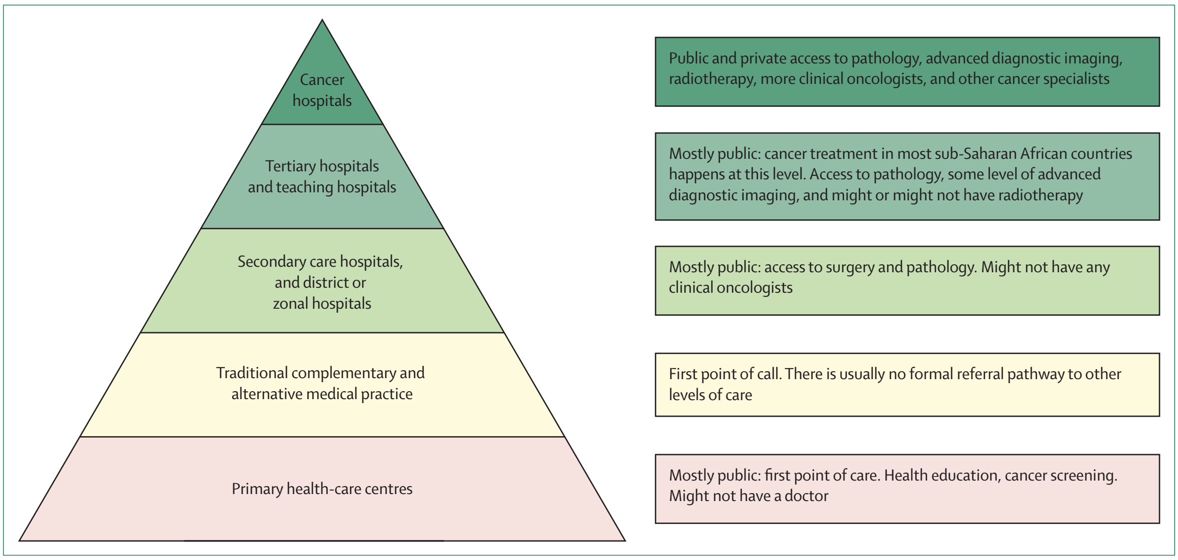


Figure 11: Levels of care for cancer in sub-Saharan Africa

of the programme to a wider mission of Medical Education Partnership Initiative—as opposed to a focus on HIV and AIDS alone—has further accelerated this improvement.[299,300] However, there has been a progressive reduction in funding from bilateral and multilateral institutions due to the rise in the growth of GDP of some countries to levels that make them ineligible to receive donor funding. Despite these funding reductions, the development spending per capita on health in SSA continues to surpass financing from governments. At the same time, out-of-pocket medical expenses account for the largest share of health spending. In the most extreme cases, some countries are almost exclusively dependent on aid.[301] This funding structure has impeded the prioritisation of cancer control funding in many SSA countries since most foreign funding sources tend to prioritise sexual and reproductive health, infectious diseases, and vaccines, rather than cancer control efforts.[302]

The health-care systems in SSA are complex and rapidly evolving. Even though there have been advances in diagnostics and treatment capabilities, many gaps remain that need to be addressed. The degree of required improvements differs from country to country as there are huge disparities within and between countries. For example, the health-care system for cancer in South Africa is much more advanced than in neighbouring Zimbabwe.[303,304] However, almost universally, the primary health-care centres are the first point of call in the system for cancer prevention through screening and health education. Nonetheless, data suggest that alternative pathways such as visits to traditional medical practitioners or faith-based institutions precede hospital visits when the first cancer symptoms are noticed (Ndoh KI, unpublished). Access to high-quality primary health care will ultimately reduce the high prevalence of late-stage cancer diagnosis and improve treatment outcomes for patients through early diagnosis and prompt referrals. Figure 11 shows the different levels of care in the cancer control pathway.

Traditional, complementary, and alternative medical practices and the health-care system in SSA

In the SSA context, traditional, complementary, and alternative medical practice (TCAMP) refers to indigenous practices using plant, animal, spiritual, and manual therapies that are based on beliefs, theories, anecdotal evidence, and culture to prevent, diagnose, and treat physical and mental health disorders.[305,306] The transition to the adoption of orthodox medical care never completely displaced TCAMP or made it mutually exclusive. For example, one study in Ethiopia showed that 90% of the population visits a TCAMP when ill.[307,308] Even more striking was a 2019 survey among pharmacists in Nigeria that showed that more than half of those surveyed visited TCAMPs.[309] When health policy makers ignore TCAMPs, we are likely to be missing a unique window of opportunity to diagnose cancer early through referrals from TCAMPs to tertiary health-care centres or the potential to discover new cancer therapies from herbal extracts.

The incorporation of TCAMP into orthodox medical care has long been championed by WHO and was a key part of the strategy for universal health coverage for Africa. In 2000, the WHO Regional Committee meeting for Africa urged member states to develop policies and legislations governing the use of traditional medicine as part of its resolutions.[310] South Africa, a large economy, is one of the few countries that has taken concrete steps to implement these resolutions. The key policies that have been implemented in South Africa are: (1) a national drug policy in funding the efficacy, safety, and quality of traditional medicine; (2) the establishment of a National

Panel 12: Rwandan model of universal health coverage

Rwanda has long been touted as a global health model, especially in primary health care through their home-grown community-based insurance scheme. After the genocide in 1994 that led to the death of about 1 million Rwandese people—nearly 20% of the population at the time—the health-care system was mostly moribund. 28 years later, Rwanda has made remarkable progress in rebuilding its health-care system. In the context of cancer and universal health coverage, there are lessons to be learned from Rwanda that could be adapted and scaled to other countries in sub-Saharan Africa.[315,316]

Coverage of primary health-care services

As mentioned previously, Mutuelle de Sante is a community-based health insurance scheme targeted at low-income citizens. Premiums ranging from US$2 up to $7·5 are paid to the Rwandan Social Security Board accounts. Through a traditional system known as the Ubudehe system, the community categorises each household based on income and vulnerabilities. The lowest income earners pay the lowest premiums and are subsidised by the government and development partners. This insurance scheme covers cancer prevention services such as pap smears, ultrasound screening, and mammography. It has also paved the way for human papillomavirus and hepatitis B virus vaccinations for the prevention of cervical and liver cancer by incorporating them into the Rwandan immunisation schedule. This inclusion has led to human papillomavirus vaccination rates in Rwanda reaching over 93%—one of the highest in the world. Funding cancer treatment remains financially toxic for most Rwandese people because community-based health insurance cannot cover some aspects of treatments.[30,317]

Palliative care policy

About 20 million people die each year in low-income and middle-income countries with severe pain that would have been addressed with morphine. Rwanda took the lead by becoming the first African country to provide access to palliative care for free. They did so by developing the capacity to produce and distribute morphine under strict government control rather than relying on complex import systems that raised morphine prices by up to six times the cost in North America.[121,156]

Car-free days

The Rwandan Government holds a car-free day bimonthly event that is aimed at promoting a healthy lifestyle through a series of health-related activities. It was started in 2016, to help reduce the incidence of non-communicable diseases. Activities that occur on this day include: no driving of cars, public exercise events, health screens, and others. Since then, other countries such as Kenya, Ethiopia, Uganda, and Zimbabwe have now introduced their own versions of car-free days.[318]

Reference Centre for African Traditional Medicines; (3) the appointment of a presidential task team in 2006, to draft the regulatory and legal framework on TCAMPs, leading to the Traditional Health Practitioners Act in 2008; and (4) the establishment of the Directorate of Traditional Medicine. This agency was tasked with coordinating all TCAMP activities and policies at several government agencies and departments.[311]

Similarly, Nigeria also established a fully fledged Department of Traditional, Complementary, and Alternative Medicine (TCAM) in the Federal Ministry of Health, Abuja, in April, 2018. An executive bill passed by the Federal Executive Council is awaiting the approval of the National Assembly. The vision of the TCAM department is to see the practice of TCAM in Nigeria become a respected mode of treatment, preserving cultural heritage with respectable practitioners and providers, delivering quality health care to all Nigerians, and providing a pathway to new drug development and commercialisation.[312]

Funding for cancer and universal health coverage

The most common limitation to accessing cancer care and treatment in SSA is the exorbitant treatment costs for patients and their relatives.[305] Occasionally, governments and some non-profit organisations arrange screening services. Despite this, most of the programmes are not sustainable. Given multiple competing developmental needs and other health priorities, cancer control in SSA has received inadequate funding and support despite the growing burden of the disease.[306,307] SSA governments must realise that long years of consistent commitment and funding are required to build and maintain a dedicated oncology workforce.[308] Universal health coverage has been adopted in a few countries, such as Rwanda, to facilitate screening centres for cervical cancer. However, further follow-up and management of positive results appears to have received little or no attention. According to Carrin and colleagues,[313] enhancing pre-payment for health services through the introduction of risk pooling while determining household contributions according to the ability to pay are core guiding principles of universal health coverage which, if properly implemented, will contribute positively to sustainable funding and reduced health-care cost.[313] In 2020, Nigeria established a Cancer Health Fund to assist patients on low incomes in paying for cancer care. It has the ultimate goal to be incoporated into the National Health Insurance Scheme.[314]

Universal health coverage funding models for expanded access to cancer control

Expanding and funding affordable and high-quality cancer prevention and treatment could be approached from a cost–benefit perspective, by prioritising the funding of vaccine-preventable cancers such as cervical and liver cancers, which is by far cheaper than funding treatment for these diseases.[30] Rwanda (panel 12) funds these prevention efforts through the Mutuelle de Sante system, which is financed by donor funding, government revenue, household premiums, and formal sector payroll.[319]

Funding innovative technologies in cancer control has the potential to expand access, reduce costs, and provide high-quality evidence-based preventive and treatment services to patients. There is a growing body of evidence that the use of these technologies in cancer diagnosis and treatment is improving outcomes for patients with cancer in some SSA countries. For example, Mulago Hospital, Kampala, Uganda, in partnership with Fuerth hospital in Fuerth, Germany, has recorded improvements in diagnostic accuracy using telepathology.[320] Botswana, through a partnership with the American Academy of Dermatology, has implemented a teledermatology programme that helps provide support to local physicians and dermatologists.[321]

Funding affordable cancer therapies and diagnostic technologies

There is an inextricable dependence on health financing, quality of oncology training, and availability and use of effective drugs and technologies for the diagnosis and treatment of cancers in SSA. Without the requisite training, the appropriate drug combination needed for a particular cancer is most likely not to be prescribed or could be used incorrectly. Furthermore, with low funding for health care and insurance, novel and more targeted therapies are likely to be unavailable.[322,323] These persisting challenges in access to affordable effective cancer treatments have given rise to a growing number of public–private partnerships. One such partnership is the Glivec International Patient Assistance Program, a collaboration between Novartis and the Max Foundation that provides imatinib for free to many countries in Africa.[324] Another example involving leading pharmaceutical companies is the partnership between Pfizer, Cipla, the American Cancer Society, the African Cancer Coalition, and the Clinton Health Access Initiative, which was set up in 2017 to improve access to 16 WHO-designated essential cancer drugs in Ethiopia, Kenya, Nigeria, Uganda, Rwanda, and Tanzania. These countries account for 44% of the cancer burden in Africa. The financial model for this collaboration works through a revolving fund. The pharmaceutical companies provide the drugs at a substantially reduced price without an initial upfront payment from the government and are reimbursed when patients purchase the drugs out of pocket or through government insurance schemes.[325] Local manufacturing of biosimilars could offer a long-term sustainable solution for access to affordable high-quality cancer drugs. In 2019, the Seattle-based Infectious Disease Research Institute partnered with the South African biotech company Afrigen Biologics and Vaccines, to produce mass quantities of their tuberculosis vaccine candidate ID93+GLA-SE. Although not directly related to cancer, this partnership shows that biosimilars and generics can be produced at low costs and potentially scaled up.[326] The 2017 partnership model could be considered or adapted for other treatment modalities, such as radiotherapy.

Pooled procurement system as a way of financing drugs and equipment

The pooled procurement system helps to combine several buyers into a single entity to purchase a single unit. For example, improving cervical cancer control requires that patients and their health-care providers have unrestricted access to affordable vaccines, diagnosis, and treatment options. When regional blocs in SSA combine their resources into a single buying bloc, the laws of demand effectively drive down the prices and substantially increase access to drugs, vaccines, and equipment. The same principle worked in the procurement of antiretroviral drugs.[324,327] Places with pooled procurement models that consolidate purchasing across national boundaries have several benefits, including (1) reductions in unit purchase prices; (2) improved quality assurance; (3) limited corruption in procurement; (4) rationalised choice through better-informed selection and standardisation; (5) reduction of operating costs and administrative burden; (6) increased equity between members; (7) augmented practical utility in the role of the host institutions (regional or international) administering the system; and finally, (8) increased access to essential medical products within each participating country.[328] Such pooled procurement was exemplified during the COVID-19 pandemic to enhance capacity to access vaccines,[329,330] and should be seriously considered in cancer prevention and control efforts in SSA.

Public–private partnerships in funding cancer centres

The relatively low per-capita expenditures on health and the competing health demands in SSA greatly reduce countries' ability to fund and sustain regional cancer centres. The model that has shown some successes is when cancer centres are jointly funded by the private sector and governments. For example, many radiotherapy machines installed in several teaching hospitals in Nigeria in 2007, broke down within 10 years of installation. The Fred Hutch–Ugandan Cancer Center in Uganda, the Lagos University Teaching Hospital–Nigeria Sovereign Investment Authority Cancer Centre in Nigeria, and the Butaro Cancer Centre in Rwanda are examples of public–private partnerships that have successfully addressed the burden of cancer.[331,332]

There are lessons to be learned from the two examples in panel 13. First, implementing public–private partnerships in the establishment of cancer centres must be set up so that all partners and stakeholders are winners.[338] In the first model, the Fred Hutch centre expanded its ability to have physicians trained in global oncology and conduct research. Meanwhile, Uganda leverages this collaboration to increase diagnostic, treatment, and research capacity for the overall benefit of the patient. In the second model, the Nigeria Sovereign Investment Authority projects a generous return on investment in 10 years, while Lagos University Teaching Hospital can improve its cancer treatment capabilities and business operations.[337,339] Second, all public–private partnerships must be set up with operational sustainability in mind. Some studies have shown that one-off donations or training are usually unsustainable and do little to improve capacity. In the two models referenced here, there were comprehensive business plans and frameworks backed by adequate funding to ensure long-term sustainability.[339,340] Third, public–private partnerships should have a goal of becoming model regional or national reference cancer centres to train the next generation of oncologists and cancer care professionals who would serve patients with cancer in the country and region. The two referenced models in panel 13 exemplify this lesson.[331,341]

Panel 13: Examples of public–private partnership models

The Ugandan Cancer Institute is a publicly funded comprehensive cancer centre in Kampala, Uganda. Founded in 1967, it is one of the oldest comprehensive cancer centres in sub-Saharan Africa.[333] In 2008, the Ugandan Cancer Institute officially partnered with the Fred Hutch Cancer Center in Seattle, WA, USA.[334] The scope of the partnership covered the following areas: conduct high-impact research to reduce cancer-related deaths and suffering; train the next generation of Ugandan oncology and haematology leaders in cancer research and clinical care; build laboratory capacity for basic, translational, and clinical research; and contribute meaningfully to the advancement of quality care.[334]

The partnership heralded clinical and research training programmes for Ugandan and Seattle oncologists, nurses, and researchers, interdisciplinary tumour board meetings, and numerous high-impact research projects. In 2018, the Ugandan Cancer Institute, the Fred Hutch Cancer Centre facility and the University of Washington, Makerere University, and Mulago Hospital launched an adult haematology–oncology fellowship programme. Perhaps the most visible aspect of this partnership is the establishment of a US$10 million state-of-the-art Ugandan Cancer Institute–Fred Hutch Cancer Centre facility, launched in 2015, in Kampala, Uganda. This resource was the first comprehensive cancer centre jointly built by US and African cancer institutions in sub-Saharan Africa. The facility features outpatient services, research, training, and biomedical laboratories, which are needed to address the growing cancer burden. The United States Agency for International Development and the Fred Hutch Cancer Centre facility contributed about a third of the total funds (US$7 million), with the Government of Uganda contributing the rest.[334]

Another example is the partnership between the Nigerian Sovereign Investment Authority and Lagos University Teaching Hospital (Lagos, Nigeria). The Nigerian Sovereign Investment Authority is an agency of the Federal Government of Nigeria set up to manage funds accruing more than budgeted oil revenues. The act establishing the Nigerian Sovereign Investment Authority empowers it to receive, manage, and invest funds in a diversified portfolio on behalf of the Federal Government of Nigeria.[335] In 2019, the Nigerian Sovereign Investment Authority invested US$11 million into the Lagos University Teaching Hospital to build and upgrade facilities to become a fully functional cancer centre. This investment empowered the hospital to provide advanced radiotherapy and chemotherapy services. The Nigerian Sovereign Investment Authority Health Development and Investment Company runs the day-to-day business operations and is expected to transfer 100% ownership to Lagos University Teaching Hospital in 2029. Before the investment into the hospital, Nigeria had only about two to three functional radiotherapy units for a population of 200 million people. With the partnership, this number was increased by two additional high-energy beam linear-particle accelerators and one halcyon unit.[332,336,337]

When considering public–private partnerships, it must be determined if such a partnership is the right model for success. These partnerships tend to work better in government-funded cancer centres that are weak from limited financing.[301] Roles and responsibilities, intellectual property governance frameworks, equity ownership, business operations, initial and subsequent financing, financial governance, and legal frameworks should be deliberated upon, clearly defined, and signed by both parties.

There should be mutual respect, resource appropriateness, and cultural sensitivity in implementing these partnerships, especially in the context of high-income and low-income country partnerships, and the increasing role of global, regional, and local corporate actors who might see the African cancer burden as a growing market open for financial exploitation. Finally, there should be a detailed plan and mechanisms for monitoring and evaluating from the beginning of the partnership to ensure positive outcomes, especially for SSA partners.

Cancer care and health-care systems in regions affected by conflict

As of 2021, there were no less than 20 countries in SSA plagued with major conflicts, such as Chad, Central African Republic, Somalia, South Sudan, and Sudan.[342] The health-care systems in areas of conflict are often fragile and heavily donor-dependent, leading to priorities that are tilted towards donor priorities. Funds are often deployed to tackle the more obvious public health challenges such as maternal and child health issues of delivery, family planning, malnutrition, infectious diseases, conflict-related injuries, and immunisation.[343] Awareness of cancer has been reported to be very low in these regions. One study in Democratic Republic of the Congo showed that less than 20% of women interviewed knew the cause of cervical cancer or how it was prevented or treated. Only 9% had ever had a pap smear.[344] Similarly, cancer survival in such areas is very poor. A 2019 study in northeastern Nigeria, facing the Boko Haram insurgency, showed that the median survival time for patients with cancer (all cancers considered) in the University of Maiduguri Teaching Hospital—the largest tertiary hospital in the region—was only 26 days.[345]

A cancer control model implemented in Democratic Republic of the Congo by Parham (a US gynaecologist based in Zambia) and his team identified the following strategies to be of greatest impact for improving outcomes in breast and cervical cancers: (1) screening for cervical cancer using visual inspection with acetic acid and visual cervicography; (2) thermal ablation and large loop excision of the transformation zone of cervical cancer precursors; (3) clinical examination of symptomatic women using clinical breast examination and breast ultrasound; (4) surgical treatment of cervical and breast cancers, including breast oncoplastic procedures; (5) palliative surgery; and (6) infusion of chemotherapy for advanced cervical and breast cancer.[344]

The role of professional organisations

Professional organisations, such as AORTIC, have implemented capacity-building programmes in several aspects of cancer prevention and treatment through research. Furthermore, the African Cancer Coalition and other professional associations such as the Association of Radiation and Clinical Oncology in Nigeria have been involved in the development of the NCCN harmonised SSA guidelines.[346–348] More engagement with professional societies, including with partner societies in high-income countries, is recommended, for example in providing educational material to enhance capacity building.

New developments in cancer control

There are emerging interventions that have been deployed to prevent and treat specific cancers in high-income countries, which have not been introduced or fully implemented in SSA. These interventions include mobile applications to augment data repository, telemedicine and robotic medicine, modular competency-based capacity building for specialists, and tertiary or quaternary precision treatment trials. In Rwanda, Botswana, and South Africa, mHealth is being used to collect information, schedule appointments, and offer consultations to women with cervical and breast cancer living in rural communities or other difficult-to-reach areas.[349,350] A major limitation of mHealth platforms is the inability of the physician to perform a physical examination; nonetheless, it democratises access to screening and expert consultations in the context of the relatively low oncologist-to-patient ratios prevalent in SSA. Some countries such as Rwanda and Uganda have robust mHealth platforms in their cancer centres, where oncology specialists share information, including developing guidelines.[351,352] Rwanda is investing heavily in drones to improve logistics in blood supply, vaccine delivery, and specialised laboratory services.[251,352,353] This investment could be extended to oncology services, particularly in SSA where transport and infrastructure deficits remain a challenge. Countries in SSA investing in cancer care would benefit from inexpensive and effective training programmes for aspiring oncology professionals and continuous medical education for certified specialists. Many countries in SSA favour competency-based training programmes with hands-on experience as a more cost-effective strategy than sending professionals abroad for observership-based training.[251,354–356]

Conclusions and call to action

On March 11, 2020, WHO declared the COVID-19 global health crisis a pandemic. In response to COVID-19, SSA countries instituted lockdowns and restrictions that limited activities for primary cancer prevention, screening, diagnosis, and treatment, and the consequences for cancer prevention and control in SSA are expected to be substantial. For example, COVID-19 travel restrictions meant children with cancer had their treatments delayed. A WHO study[3,4] has already reported that 28 000 children died from cancer in Africa in 2020, during the COVID-19 pandemic. Given the expected projected mortality in children aged 0–14 years for 2020, of 21726 (table 1), this estimate represents an increase in mortality of 28·8% or about 6274 excess child deaths in 2020. This increase in deaths is consistent with recent work[357] that has reported that the COVID-19 pandemic had a substantial impact on paediatric cancer care worldwide. Overall, it can be concluded that there will be an increase in mortality from cancer due to COVID-19, in addition to the cancer deaths already projected, highlighting the urgent need to strengthen health-care systems in SSA.

Dealing with the pandemic also highlighted opportunities where greater action, investment in, or adoption of recommendations could substantially benefit access to cancer care in SSA.[358] For example, because of COVID-19, many professional societies such as the NCCN recommended that, for radiotherapy used in the treatment of more than 50% of patients with cancer, evidence-based hypofractionated radiotherapy should be adopted. Hypofractionated radiotherapy involves the delivery of substantially fewer fractions of radiotherapy at larger (>2 Gy) doses compared with conventional radiotherapy, and so this recommendation was made to help alleviate stress on staff in situations of personnel reductions. On the basis of recent publications on moderate and ultra-hypofractionated radiotherapy,[359,360] we estimate a substantial increase in access to radiotherapy by implementing such evidence-based hypofractionated radiotherapy for some of the leading cancers in Africa, such as breast and prostate cancer.[142,359] For example, for ultra-hypofractionated radiotherapy,[360] this inclusion could lead to an increase of up to 400% in access for patients with intermediate-to-high-risk prostate cancer. Furthermore, our analysis, following methods described in recently published work[142] but covering the next 10 years (2021–30), shows the estimated cost savings per treatment would also be substantial (appendix p 19). The projected potential cost savings in Africa with full hypofractionated radiotherapy implementation would be in the billions of US dollars (table 7). Another benefit of reducing treatment delays via hypofractionated radiotherapy could be in increased survival.[361] Other approaches that could increase access to radiotherapy have also been reported and should be encouraged.[127]

Another major opportunity highlighted during the COVID-19 pandemic is with advanced information and communication technologies that present rapid ways to increase access to health care in SSA. COVID-19 restrictions coerced accelerated adoption of advanced information and communication technologies in African countries, for telemedicine and oncology. Different sections above have already highlighted the benefits of leveraging this technology, from cancer prevention to diagnosis, through treatment, palliative care, research, and education. Digital health is already being adopted at a high rate, as seen in Nigeria and South Africa[362] including in cancer care, where teleoncology has become a necessity for providing remote chemotherapy supervision, symptom management, and palliative care to many patients with cancer. With shifting attitudes towards telemedicine, remaining challenges to greater adoption of these technologies include regulatory challenges, need for more infrastructure, linguistics, and the fact that teleoncology cannot be extended to all patients. In the future, better policy and increased infrastructure and training to use information and communication technologies will be

	National radiotherapy access in 2020 (%)*	Breast cancer (2020–30)		Prostate cancer (2020–30)	
		Projected national cost for full access to breast radiotherapy at conventional fractionation (US$ million)	Projected national cost savings with hypofractionated breast radiotherapy (US$ million)	Projected national cost for full access to prostate radiotherapy at conventional fractionation (US$ million)	Projected national cost savings with hypofractionated prostate radiotherapy (US$ million)
Angola	53·0	514·3	20·7	47·1	2·3
Benin	7·1	35·7	14·1	30·0	14·3
Botswana	10·9	4·0	1·6	1·6	0·7
Burkina Faso	6·9	34·3	13·4	15·7	7·4
Burundi	3·1	15·7	6·0	17·1	8·3
Cameroon	77·7	757·1	30·1	48·6	22·9
Cape Verde	0·1	1·0	0·4	1·9	0·9
Central African Republic	2·4	12·1	4·9	6·9	3·3
Chad	7·7	38·6	15·6	12·9	6·1
Comoros	0·2	1·0	0·4	1·1	0·6
Côte d'Ivoire	61·4	614·3	24·6	54·3	25·9
Democratic Republic of the Congo	51·4	257·1	57·7	130·0	62·3
Equatorial Guinea	0·3	3·0	1·3	2·0	1·0
Eritrea	3·4	17·1	6·9	2·0	1·0
Eswatini	0·2	1·7	0·7	1·7	0·9
Ethiopia	71·9	357·1	142·9	37·1	18·0
Gabon	12·3	4·0	1·6	4·1	2·0
Ghana	12·9	104·3	42·0	47·1	22·6
Guinea	0·3	1·4	5·6	20·0	9·6
Guinea-Bissau	0·8	3·9	1·6	1·7	0·9
Kenya	18·1	142·9	58·3	67·1	31·9
La Réunion, France	1·2	7·7	3·1	9·4	4·4
Lesotho	0·3	3·1	1·3	2·6	1·1
Liberia	6·9	9·6	3·9	8·3	4·0
Madagascar	8·2	31·4	12·6	40·0	19·3
Malawi	5·7	28·6	11·7	11·3	5·4
Mali	9·6	41·4	16·4	11·6	5·6
Mauritania	6·3	9·4	3·9	4·7	2·3
Mauritius	21·1	13·6	5·4	4·0	2·0
Mozambique	7·1	31·4	12·6	37·1	17·6
Namibia	19·6	7·3	2·9	4·6	2·1
Niger	8·8	38·6	15·3	4·0	2·0
Nigeria	61·2	600·0	239·1	285·7	138·1
Republic of the Congo	0·9	9·1	57·7	11·6	62·3
Rwanda	5·4	27·1	10·6	17·1	8·1
São Tomé and Príncipe	0·0	0·3	0·1	0·3	0·1
Senegal	12·8	41·4	16·4	21·4	10·0
Sierra Leone	4·6	22·9	9·4	8·4	4·0
South Africa	59·3	300·0	121·7	271·4	128·9
South Sudan	12·3	32·9	12·9	15·7	7·6
Tanzania	15·9	71·4	28·9	97·1	46·7
The Gambia	0·2	1·1	0·4	0·7	0·3
Togo	3·4	17·1	6·9	7·0	3·3
Uganda	12·5	57·1	22·9	47·1	22·6
Zambia	3·5	21·4	8·7	27·1	12·9
Zimbabwe	10·3	44·3	17·9	27·1	13·0
Total	NA	4388·8	1093·1	1525·3	766·6

NA=not applicable. *Details of how the national radiotherapy access percentage was calculated are given on p 2 of the appendix.

Table 7: **Potential national cost savings and increase in radiotherapy access with adoption of evidence-based hypofractionated schemes for breast and prostate cancer in sub-Saharan Africa**

essential. Collaborations with information and communication technology companies to invest more in this approach would be valuable. There are already emerging visions of building comprehensive cancer centres in the cloud (ie, C4, which is an online platform for cancer care, research, and education) for Africa with opportunities for international collaboration,[51] accessible from anywhere for consultations, second opinions, follow-up, and continuous education, which can also leverage artificial intelligence.[363] The C4 launched by the Global Health Catalyst win–win initiative has already developed an effective model demonstrating how information and communication technologies can be leveraged to advance oncology care research and education in Africa.[264,364,365] The use of tele-oncology for two to three follow-up visits per year during treatment can save each patient substantial costs besides the benefits in terms of patient convenience. Given the surge in cancer cases per year, the cumulative benefits would be even greater. Therefore, increased information and communication technology investments, building on advances made during the COVID-19 pandemic, could be tremendous for advancing oncology in SSA and strengthening the health-care system.

The use of technology has also provided major opportunities for greater involvement of the African diaspora in oncology initiatives in SSA, with the potential to turn brain drain to brain circulation and global health gain. The African Union defines the African diaspora as all people of African descent living outside Africa, with the African diaspora considered a sixth region of the African Union. Recent work[264,365] has highlighted the benefits of involving the African diaspora in areas such as tele-oncology, online education, research collaborations, and even in innovative approaches for health-care financing.[134] Beside the fact that the SSA diaspora are inherently stakeholders in health care in SSA, the diaspora has tremendous financial potential that can benefit SSA as seen with tens of billions of US$ in remittances per year and diaspora groups building cancer centres in African countries.[264,366–368] Policies in more effective engagement of the diaspora in addressing the growing cancer burden in SSA (appendix p 14) are therefore encouraged for each country. The African Union can also play an important role to support such engagement in ways that facilitate pan-African collaboration in the fight against cancer, as seen with the Africa Centres for Disease Control and Prevention leading Africa-wide efforts against COVID-19.

In considering a call to action, we remember that by adopting the World Health Assembly resolution on cancer in May, 2017, WHO reiterated the importance of country-specific NCCPs and sustained government commitments to funding the implementation of the NCCPs.[369] As of 2019, 29 (60%) countries in SSA had an operational policy, strategy, or action plan for cancer—a substantial improvement from 2013, when only 14 (30%) SSA countries had a published response to cancer.[370] Although the number of SSA countries with operational cancer plans has increased, some of these plans set unattainable targets with available resources and these plans might need to be updated or more resources allocated for implementation. Furthermore, those countries that do not have a plan yet are encouraged to create one as soon as possible.

A call to action

We have drawn on the wisdom and practical experience of the widely acknowledged leaders, representing the spectrum of cancer control, who have contributed so generously of time and intellect to this Commission. We define our call to action as an exhortation to the many and varied players that we require to cooperate to improve cancer control in the nation states of SSA, to achieve the aims that we specify below, and to build robust health-care systems that will address the increasing cancer burden.

We acknowledge that much has been written in the recent past about cancer in Africa, that committees have been formed, that the good and great have opined, yet the plight of most patients with cancer and their families remains much the same. There is a tendency to confuse activity with action, and rather than wait endlessly to deliver the perfect plan, we recommend that urgent action is taken, where possible, to initiate workstreams that return good outcomes in the more immediate term.

We realise and understand the many demands made upon health and finance ministers, all of whom seek to deliver the best health care that they can for their own citizens within the often limited resources available, but we are driven by our deep knowledge of the disease, certainty that cancer is becoming a major health problem, and that a concerted effort to reduce the incidence of NCDs will carry economic benefits to those countries that are best prepared.

To some extent, we are cancer lobbyists in that we aim to influence public officials, especially members of legislative bodies, and sway public opinion but we do so from a position of professional expertise, of available evidence, and a profound sense of timeliness. We have seen too many reports, too many words, too many good intentions, too many families torn apart, and too many excruciatingly painful deaths to see yet more delays in taking collective action to accelerate cancer control in SSA.

We have compressed the various elements in the preceding sections to apply effective use of resources for cancer prevention and to enable health-care providers to deliver and sustain high-quality cancer services for patients with cancer and their families. We place value at the centre of our recommendations and have underpinned our advice throughout the Commission with the sense that the perfect is the enemy of the good, leading us to promote that which we believe is practicable and achievable, rather than that which might represent an ideal, but which might be beyond the reach of most African citizens.

Although there are core pillars around which our call to action is based and a strong case for transnational

Panel 14: Calls for urgent action

Action one: precision cancer control planning

Develop or update national cancer control plans and provide sustained financing, to ensure their implementation

Metrics: implementation of the national cancer control plans

Timeframe: within 5 years

Action two: improving data acquisition and cancer registration

Invest in cancer registration to provide data upon which rational cancer planning will be undertaken

Metrics: establish and support national cancer registries

Timeframe: within 3 years

Action three: designing health-care systems that promote equity of access

Expand universal health coverage, incorporating cancer care into essential benefits packages and national health insurance systems to reduce out-of-pocket expenditures for essential therapies for citizens with cancer

Metrics: sub-Saharan African countries to incorporate cancer care into universal health coverage

Timeframe: within 5 years

Action four: increasing cure and improving care

Pilot early cancer screening and detection programmes that make use of point-of-care technology delivered by allied health professionals, accompanied by mobilisation of resources to provide affordable, adequate, and value-based cancer treatment

Metrics: substantial decrease in the number of patients with late presentation; decrease time between diagnosis and treatment; increase the percentage of patients with cancer receiving appropriate treatment as delineated in national guidelines

Timeframe: within 5 years

Action five: effective palliation

Include palliative care as an integral and key part of cancer care as, in the medium term, the majority (70–80%) of African patients with cancer will present with advanced stage IV disease where often palliative care provides optimal management

Metrics: established integrated programme of supportive care and rehabilitation with optimal and equal access to opioids for patients with cancer

Timeframe: 1–3 years

Action six: building and maintaining the workforce

Establish relevant training programmes for health-care and allied professions; increase the number of individuals attending and gaining certification from various programmes; develop community-based awareness raising programmes; establish mechanisms for mitigating brain drain including through cooperation between governments, better conditions of employment, and incentives to retain talent

Metrics: established oncology training programme in each country to build capacity for oncology needs; substantial increase in the number of health-care professionals committed to delivering cancer control programmes

Timeframe: 3–5 years

Action seven: innovation and research

Establish national cancer research institutes and committees with agreed funding streams; develop international collaborations and external partnerships

Metrics: established centre of excellence or research network in each country

Timeframe: 1–3 years

Action eight: invest in telehealth

Expand the use of digital health solutions to address the growing cancer burden and disparities

Metrics: increased investment in telehealth; increased governmental support with reliable infrastructure and policy, as well as regulations related to successful implementation and use of digital health solutions

Timeframe: 1–3 years

cooperation, there is not a one size fits all solution that can be imposed on individual nation states—one might say that we need to take an individualised public health approach, paralleling modern, precision cancer medicine in which we aim to deliver the right treatment to the right patient at the right time. Panel 14 summarises the calls to action.

Action one: precision cancer control planning

Governments need to develop and consolidate NCCPs with sustained financing to ensure their implementation. Although the core structure of each NCCP will be broadly similar, they should be data driven, where possible, and tailored to meet the needs of their citizens, with deliberate inclusion of priorities for childhood cancer control, considering the recommendations made in different sections of this Commission. This action is an area that will benefit greatly from shared knowledge. WHO has produced a range of excellent guides on cancer planning, but these are necessarily generic and we have no doubt that health ministries and NCCP teams pooling their own practical experience, on what does and does not work, will accelerate progress. Creating a central repository of best practice would facilitate international collaboration and build on existing NCCPs, which have already been constructed in some African countries.

Emphasis should be given to those elements that are considered most cost-effective, for example WHO's best buys, that are prioritised and costed by the National Cancer Control Committee, which we recommend comprises senior government officials (eg, finance, health, and education ministries), clinicians, epidemiologists, non-governmental organisations, economists, and representative patient groups. We understand that each nation state will have to make their own financial reparation, so we have deliberately avoided making statements that we need to train specific numbers of doctors and nurses, install specific numbers of radiotherapy machines, or expend billions of dollars to achieve parity with those wealthier nations. Instead, let us trust in the collegiate cancer planning for each country, certainly overlapping, but individual to each nation's needs.

We must emphasise that creating or updating a cancer plan for a country is not the objective. It is a method to achieve the collective goal of improved outcomes for citizens. Too often we have observed that carefully crafted cancer plans gather dust on the shelves of ministries rather than be animated as living documents that are part of the DNA of cancer services—owned by the policy and health professionals who are signed up to their delivery.

This action can be achieved through three phases. Phase one includes undertaking a situational analysis of current cancer control based on epidemiological evidence and a review of relevant policies, programmes, and facilities. This step will also involve formulating an action plan for the prevention, management, and control of cancer, delineating specified goals, objectives, and activities, and consulting with relevant stakeholders. A refined NCCP serves as a roadmap for activities across all sectors to facilitate comprehensive and integrated cancer control. This phase should take 12–18 months to complete. Phase two involves establishing clear goals and outlining strategies and timelines to achieve these, which should be completed within 6 months. And phase three is establishing a group or organisation to monitor and evaluate the plan, which should take place over 3–5 years.

Action two: improving data acquisition and cancer registration

This aim requires investment in cancer registration and improved data collection from the clinical front line to provide information upon which rational cancer planning will be undertaken. There is good practical support from organisations such as WHO and IARC in this field and every health ministry should take advantage of their funding, training, and expertise. The registries must include childhood cancers and provide a dynamic oversight for the NCCP committee, so that progress can be monitored to assess the effectiveness of each of the interventions that the Commission recommends, eg, migration from presentation with stage IV to earlier stage disease; and analysis of 1-year cancer survival rates to measure the impact of treatment.

To achieve this action, countries need to establish and support a national cancer registry, and provide the best available epidemiological data (eg, stage at presentation and 1-year cancer survival rates) to inform situational analysis. The timeframe to build a fully functioning registry, provide support to clinical centres to enable data collection, and to provide the first set of agreed cancer statistics to the NCCP committee is 1–3 years.

Action three: designing health-care systems that promote equity of access

This action involves incorporation of cancer screening and treatment, including childhood cancers, into essential benefits packages and national health insurance systems when expanding universal health coverage, to reduce out-of-pocket expenditures for essential therapy for citizens with cancer, with a view to avoiding catastrophic bankruptcies and abandonment of treatment.

We support the access of all patients to the WHO list of essential cancer medicines, implementing research that shows cost-effective radiotherapy regimen, and applaud those professional societies that are working to deliver cost-effective treatment guidelines in partnership with our African colleagues including AORTIC, the American Society of Clinical Oncology, the European Society for Medical Oncology, and the NCCN, which have made efforts to this effect and introduced the concept of value-based management options.

Programme one of implementing this action, which can take between 3 and 5 years, should include interdepartmental negotiations within governments to establish a timeline to develop a universal health coverage plan including essential cancer therapy. Programme two should, over 12–18 months, establish a working group to collaborate with guideline experts to produce value-based treatment guidelines, based on the essential cancer medicines list and reduced radiotherapy fractionation schedules.

Action four: increasing cure and improving care

Too many African patients continue to present with advanced stage IV disease that is way beyond curing, even in the most sophisticated health-care systems. Biologically, the most logical route to increase success is through earlier disease detection. We recommend piloting early cancer screening and detection programmes that make use of point-of-care technology delivered by allied health professionals. These programmes should be tailored to national needs, using cancer registries to identify cancers that are sufficiently common and should explore both low-technology and high-technology interventions. This action is an area that is ripe for collaboration between technology-rich nations and companies and African researchers working in the field. How we train workers to deliver and interpret these tests requires not only technical innovation but also lateral thinking. Cervical cancer provides a host of examples in which multidisciplinary research and implementation in Africa has the potential to be world leading.

We recognise that these actions must be accompanied by making every possible effort to mobilise resources to provide affordable adequate, value-based, cancer treatment. Otherwise, these actions would be frustrating to both patients and medical professionals.

Fear of the consequences of detecting cancer without access to affordable treatment is an important cause of late presentation.

To improve the delivery of cancer care, gap analysis of existing versus optimal services (ie, staff, equipment, and infrastructure) should be undertaken as a main component of the NCCP and a realistic investment plan constructed in 5-year cycles. Cancer care should be delivered by multidisciplinary teams, built on networks of collaborating hospitals (possibly transnationally in the early phases of implementation), driven by nationally agreed treatment guidelines, and with access to cost-effective medicines. We believe that networks with well-developed referral pathways, which could include traditional healers, trained to recognise the early signs and symptoms of common cancers, uniting community, district, and tertiary hospitals, would provide a strong system upon which to construct a stable therapeutic platform. Investment in pooled procurements as well as continuous negotiations with pharmaceutical companies and manufacturers of medical equipment will reduce the cost of cancer diagnosis and treatment. The latter point is one that would benefit from a health diplomatic union between African states.

Programme one, completed over 3–5 years, should increase the percentage of patients presenting with early-stage disease. Programme two, also achieved over 3–5 years, should ensure effective treatment and diagnosis to reduce cancer morbidity and mortality by estimating the following parameters: the time between diagnosis and treatment; the number of patients reviewed by a multidisciplinary team; the percentage of patients with cancer receiving appropriate treatment as delineated in national guidelines; and cancer registry-reported 1-year survival figures.

Action five: effective palliation

Palliative care must be considered as an integral and key part of cancer care since, in the medium term, the majority (70–80%) of African patients with cancer will present with advanced stage IV disease when early instigation of palliative care provides optimal management. We consider palliative care as a vital element of cancer care as in addition to the general issues raised in action point four, there is the vitally important issue of access to opiate analgesics which, again, needs a collaborative government response, spanning health, justice, police, and finance ministries or departments. The *Lancet* Commission for Global Pain and Palliative Care Basic Package,[161] and the American Society of Clinical Oncology resource-stratified guidelines[162] should be implemented.

To achieve this action point, over 1–3 years, a nationally integrated programme of supportive care and rehabilitation that feeds into multidisciplinary teams and legislation that supports optimal and equal access to opioids for patients with cancer needs to be established.

Action six: building and maintaining the workforce

Education and training will be the keystone of any NCCP and has enormous partnership potential—between low-income countries; high-income and low-income countries; public–private sectors; and between non-governmental organisations, professional societies, and governments. These partnerships should cover health-care workers, allied professions, civil servants, policy makers, and managers. Above all, we need to invest in community education to ensure a wider awareness that will inevitably drive the strong cancer prevention, early detection, and early diagnostic systems that we described previously.

We could ask—is there any real point in this major investment in training and education if there continues to be an exodus or flight of talent from Africa to Europe and the USA? Taking the example of pharmacology, this discipline is a matter of first-order kinetics: if we try to fill a tank of water to reach a desired level, then the mathematics are driven by rate of inflow versus outflow, size of the tank, and any constants we care to add to our equation eg, the time taken to train an oncologist. The problem with the application of this simple equation is that even if we increase input, ie, train more health-care professionals, if wealthier countries, such as the UK, develop a policy of positive recruitment of nurses and doctors to fill vacancies in the National Health Service, then the elimination rate from our model (representing flight of talent) will outpace the additional input of greater training numbers. The solution to this problem needs cooperation between governments (ie, African states who train and nations whose recruitment policies drain) and better conditions of employment and incentives to retain talent, but if we cannot reduce this efflux of essentials workers, we will never reach the workforce steady state required to support the cancer care system needed to improve cancer outcomes in Africa.

To achieve this action point, relevant training programmes for health-care and allied professions must be established; the number of individuals attending and being certified by various programmes must be recorded; and community-based awareness raising programmes must be developed, which can all be accomplished over 1–3 years. Over 3–5 years, NCCPs need to develop policy documents to reduce flight of talent, and record the total number of health-care professionals trained in African nation states and those states committed to delivering cancer control programmes for their own or neighbouring countries.

Action seven: innovation and research

Research and innovation underpin rational delivery of cancer care. African cancer researchers are keen to contribute to global cancer knowledge and to focus the wider research community on African cancer problems. A managed network would bring together Africa's leading cancer researchers from centres in each participating country to work together or with external partners, where appropriate, to develop collaborative research projects, providing funding and training opportunities, and focus particularly on those cancers that are more common in Africa and for which there are substantial unmet medical needs. Such collaboration will result in a cohort of outstanding African cancer research leaders who will contribute to global knowledge.

To do so, over 1–3 years stakeholders should establish national cancer research institutes, committees, or centres of excellence with agreed funding streams; develop international collaborations and external partnerships; and collect evidence of research outputs using conventional metrics around the number and quality of publications.

Action eight: invest in telehealth

One recurrent theme that spans almost all the separate sections of our report is the adoption of information and communication technologies, which are accelerating in use in Africa, especially in the advent of the COVID-19 pandemic and by a large proportion of young people who are eager consumers. Information and communication technologies include mobile phones, the Internet of Things (ie, the network of physical objects—things—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet) related to system development, wearables, and sensors that have opened up possibilities for new, small, and compact diagnostic tools and for easier tracking and monitoring of individuals' health in a hospital setting or underserved and remote areas. Artificial intelligence presents potential high-impact opportunities for applications in oncology in SSA. Greater investment in and leveraging of information and communication technologies will contribute to the future of health care provision, in all its aspects. These technologies will facilitate clinical trial cooperation across the sub-continent and empower implementation research: knowledge to action; knowledge translation; knowledge transfer; knowledge exchange; and research use, implementation, dissemination, and diffusion. This is a potential new area in which Africa can lead this nascent field. One avenue for investment is through public–private partnerships with the possibility of information and communication technology companies providing support packages linked to mobile phones to expand access.

This action point requires, over 1–3 years, increased investment in telehealth, increased governmental support with reliable infrastructure and policy, and regulations related to successful implementation and use of digital health solutions.

Conclusion

Our Commission was created to inquire into the state of cancer control in SSA, gather evidence supporting our claims, and provide a call to action. Given the standing of our contributory Commissioners and authors, the clarity of our recommendations and the UN-backed agenda, to reduce by a third premature mortality from NCDs through prevention and treatment by 2030, we believe that this Commission could not be more timely, with the urgent call to action for cancer in SSA to achieve this goal. Although we emphasise that individual nation states should tailor and adapt NCCPs to suit the needs of their own citizens, the current state of cancer services, and the available funding, it is equally as important to create a continental forum, perhaps under the auspices of WHO's Regional Committee for Africa or the African Union, to support transnational collaboration to share best practice, develop educational and clinical care networks, and establish cooperative research infrastructure. We repeat our call to action and urge politicians, policy makers, health-care professionals, non-governmental organisations, professional societies, and citizens to unite and chart a collective (and individual) response to the increasing burden of cancer in Africa.

Contributors

All authors participated in the writing and editing of the Commission. WN, BWA, and DK contributed to the final writing and editing of the Commission.

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JD and KG received grants or contracts from Takeda Pharmaceutical, Johnson and Johnson, AstraZeneca, Cepheid, Merck, and Pfizer as funding for specific cancer projects. JG has served as previous chair of the South African National Advisory Committee on Cancer Control and Prevention, secretary general of the International Society of Paediatric Oncology Africa, and was part of the executive committee for the South African Children's Cancer Study Group. OWB received a P30 National Cancer Institute cancer grant to Johns Hopkins University and has had a leadership or fiduciary role paid or unpaid at Lyell Immunopharma, PDS Biotech, and Grail. OWB has stock or stock options with Lyell Immunopharma and PDS Biotech. AR received the Schneider-Lesser award as a junior faculty grant. TRR served as principal investigator on grants from the National Cancer Institute including: P20 CA233255, R01CA207365, and U01CA184374. These provided support to African cancer research activities, not directly related to the Commission. TRR received consulting fees from serving on 13 US cancer centre scientific advisory boards. None of these overlap in content with the Commission. All other authors declare no competing interests.

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