

PRIZE ESSAY

FINALIST

William Wasswa



William Wasswa received a bachelor's degree from Mbarara University of Science and Technology

(MUST), a master's degree from the University of Cape Town, and a PhD from MUST, where he spent some time at the University of Strathclyde, UK, under the Commonwealth PhD split-site scholarships. He completed his postdoctoral fellowship under the Afya Bora Global Health Leadership Fellowship program and an Innovations & Entrepreneurship Fellowship from the Royal Academy of Engineering. In 2020, he started his Medical Imaging and Artificial Intelligence Laboratory in the Department of Biomedical Sciences and Engineering at MUST and a Digital Health Unit at Global Auto Systems LTD. His research and innovation work is focused on the development of low-cost digital technologies to support the diagnosis, treatment, and management of cancer in Africa. www.science.org/doi/10.1126/science.ado4541

Science | Prize for Innovation

INNOVATION

Automated innovation and impact

Online platforms promote community change, from challenge to commercialization

By William Wasswa^{1,2}

In 2015, my grandmother succumbed to cervical cancer, which was linked to a late-stage diagnosis. This incident puzzled me because she had previously undergone cervical cancer screening, and the results had turned out to be negative. In 2016, as I calibrated a microscope in the pathology laboratory at Mbarara Regional Referral Hospital, I noted how laborious, error-prone, and subjective it was to analyze Pap smears for cervical cancer screenings using a manual microscope. After I engaged with pathologists and cancer patients and reflected on the memories of my grandmother's passing, I was determined to focus on the challenges of cervical cancer diagnosis for my PhD research.

Cancer is one of the leading causes of morbidity and mortality worldwide. In total, 70% of cancer deaths occur in Africa, and Uganda ranks among the top seven countries in Africa with the highest incidence of cancer, with cervical cancer being the leading cause of death from cancer in Uganda. However, cancer can be treated if diagnosed at an early stage. For cervical cancer, a Pap smear is the commonest approach used in low- and middle-income countries (LMICs) for screening. However, the manual analysis of Pap smears under a manual microscope is time consuming and prone to error. Misdiagnosis, patient attrition during follow-up, and late-stage diagnosis are the leading causes of death among cancer patients in Uganda. These factors are attributed to the absence of low-cost digital microscopes, few available cytopathologists, and manual patient records management, which has considerable failings—e.g., inaccuracy, incomplete data, poor accessibility, and challenges for patient follow-up (1, 2). These management systems are also an inefficient mechanism for record sharing for interdisciplinary patient assessment and for monitoring quality of care to facilitate improvement, especially

in areas with low doctor-to-patient ratios, as is the case for Uganda (3). Available digital microscopes and digital oncology platforms are expensive, complex, and not designed to fit within the local clinical settings, so they have had limited impact in LMICs such as Uganda (4).

For my PhD research, I took a user-centered design approach and a design science scientific methodology to develop a digital oncology platform—the Integrated Oncology Information Management System (ONCIMS) (5). ONCIMS is a collection of software and hardware innovations that make cancer screening, diagnosis, and patient record management faster, more reliable, and more efficient. It consists of two modules: (i) PapsAI, a low-cost digital microscope slide scanner for Pap smear digitization and automated diagnosis of cervical cancer (5–7), and (ii) ONCIMS+, a data-driven oncology digital platform for cancer patients' information management (8). ONCIMS+ supports short message service (SMS) text reminders, a picture archiving and communication system, clerking, tumor boards, clinical decision support, laboratory management, pharmacy management, protocol management, human resources, inventory, case discussion, and telemedicine. The ONCIMS+ platform has been developed using a user-centered design approach and readily fits within the national cancer screening workflow. The PapsAI microscope is an automated, low-cost digital microscope and slide scanner, which quickly produces reliable and high-resolution digital Pap smears. PapsAI can be three-dimensional (3D) printed for \$300—which is quite inexpensive compared with commercial microscopes that cost \$2100. The microscope provides remote access so that cancer experts can aid in the review of a Pap smear and offer expert guidance. It also has an automated Pap smear analysis tool for diagnosis and classification of cervical cancer from Pap smears. The microscope has an objective lens from traditional microscopes, a Logitech web camera for image capture, and a motorized stage. Autofocus is driven by an algorithm based on fast Fourier transform, and stage control

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is accomplished using the Grbl library used in computer numerical control (CNC) machines. The ONCIMS+ digital platform has been developed using the Django framework, and image analysis is achieved using deep learning inspired by the Darknet architecture trained on the African population dataset that my team and I have curated using our own microscope (1, 2, 9, 10).

The ONCIMS platform has received several international recognitions: It was short-listed for the Royal Academy of Engineering's Africa Prize for Africa Engineering Innovations 2020 (11) and was included in the World Health Organization (WHO)'s Top 30 Health Innovations, and I was a finalist for the Commonwealth Secretary-General's Innovation for Sustainable Development Awards 2023 and presented at the 2020 Next Einstein Forum Global Gathering as one of Africa's brightest younger innovators. This innovation has moved from a proof of concept, to a minimally viable product supported by the Royal Academy of Engineering, to a fully-fledged digital oncology platform that is being piloted at Mbarara Regional Referral Hospital in partnership with the US Agency for International Development, the Royal Academy of Engineering, and the Uganda Cancer Institute, with an ultimate aim of it becoming the digital oncology solution of choice in the African region by 2030. On the basis of the feedback from the pilot, we are also implementing CanHub—the public face of our digital oncology platform. CanHub includes a one-stop center for cancer-related information, a social networking platform for cancer patients and care givers for coping strategies and social support, and a cancer treatment crowdfunding platform developed to support those in rural areas.

My research led to the birth of Global Auto Systems LTD Uganda, which champions digital health innovations and commercialization in Uganda. The company currently employs six full-time staff and affects communities through the implementation of digital innovations, including NextGenHIMS—the next-generation data-driven hospital information management platform that provides a streamlined hospital, clinical data, and disease management. NextGenHIMS is able to consider different diseases' clinical management workflows as well as the simultaneous presence of different databases along the continuum of patient care (12). To date, NextGenHIMS is being implemented in eight hospitals with different partners, including Doctors with Africa (CUAMM), NextGenCoviAI which was used during COVID-19 to support online hubs to manage patient data with support from WHO (13). Our 3DIY Uganda

portal (14, 15) is a digital health manufacturing platform that accelerates health care innovations through local production using 3D printing. During COVID-19, we manufactured and distributed more than 80,000 units of personal protective equipment in more than 20 health care facilities and refugee settlements in Uganda and trained more than 220 frontline health care workers with 3D printing skills with support from the Foreign, Commonwealth & Development Office. ONCIMS has evolved from PhD research to a product and now to a company that is affecting the community, with a vision to be the trusted and most reliable digital oncology solutions provider of choice in the African region by 2030. ■

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