**Title: WS3 The State of Flow Cytometry in Africa**

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**Abstract**

The need for cytometry instrumentation, reagents, training and scientific collaborations in the nations of Africa remains high despite strong efforts by both the African and foreign biomedical and cytometry research communities. Dr. Tesfa and Dr. Blanco therefore organized the first Cytometry in Africa Workshop at CYTO2019. This workshop had several goals. The first goal was to present the results of a pre-workshop survey aimed at assessing flow cytometry resources, personnel, experience and training in Africa. The results of this survey demonstrated important strengths in the African cytometry community, but also pinpointed areas where instrument access, reagent availability and training could be improved. The second goal was to present several collaborative scientific projects in Africa with participation by ISAC members. Third, both existing and proposed strategies for improving collaborative efforts and research support were presented, including cytometer donations, research collaborations and training programs. Finally, an open roundtable discussion was held with workshop attendees, many with experience in working in Africa. A diverse array of investigators from government, academia and industry attended and contributed to the workshop. A key outcome of the workshop was the establishment an African Working group in collaboration with the ISAC Instruments 4 Science Task Force, the ISAC Live Education Task Force, and the ISAC Education Committee. The workshop also marked the establishment of I4S, with the goal of advancing flow cytometry in the international research community.

**Introduction**

Instrument access, reagent and assay availability, training and education are all paramount in supporting scientists and clinicians in advancing their scientific studies in Africa. Nemes et al. (1) have indicated the need for training scientists in basic and advanced cytometry, assay developments and operational theories of cytometry instrumentation. To achieve these goals, collaborative support and dedication from cytometry researchers, shared resource managers and reagent and instrumentation vendors is critical.

The first ISAC Cytometry in Africa Workshop was organized at CYTO 2019 to get a clearer picture about the status of cytometry in Africa. It sought to identify both strengths and needs in the African flow cytometry community and highlight examples of the different actions and initiatives as well as share obstacles and outcomes. The workshop attempted to strategize mechanisms for enhancing the efficiency and impact of the limited economic and human resources available in the African countries.

The specific aims of the workshop were to review results from a recent survey of African cytometry resources and personnel, showcase existing collaborative efforts and discuss both current and new strategies for improving collaborative support and science. A further aim of the workshops was to increase awareness of the recently launched ISAC Task Force “Instrument4Science” that aims to promote and advance Science in Africa, Latin American and Caribbean countries, Eastern European countries, the Middle East, and Asian countries with economic and/or political difficulties by facilitating the donation of instruments and/or improve collaborative efforts with the local communities of these areas. This workshop constituted an excellent opportunity to collect feedback from participants and attendees on how to improve collaborative efforts in Africa.

**Method**

The State of Flow Cytometry in Africa CYTO2019 Workshop comprised of three main blocks: on-site presentation of the results of the survey, support efforts by both academic and industry scientists, discussion of current and proposed actions and plans for future activities. The first block was the introduction of pre-workshop survey results targeting the broad spectrum of clinical and research laboratories in Africa. This survey was broadly distributed to investigators throughout the African continent, as well as non-African scientists with collaborative links to African research institutions. Current and proposed efforts were presented in the second block, including donations, education, research efforts and other initiatives by both academic and industry investigators. The floor was then opened for discussion, where several significant African collaborative projects not included in the second section were described and discussed. At the end, a preliminary plan was put into place to align these efforts with the Instruments 4 Science Task Force (I4S), the ISAC Live Education Task Force, and the ISAC Education Committee.

The workshop was pleased and honored to have the participation of Howard Shapiro (via Skype), who has promoted many appropriate technologies for improved flow cytometric analysis in the developing world.

**Results**

**1.- Survey Results**

The results of this survey were presented at the workshop and are briefly summarized below (the complete results are attached as Supplementary Information W3\_Survey\_Results).

Thirty-seven survey questions were sent out to flow cytometry users in Africa. The respondents [n=42] were from all regions of Africa, the vast majority of them researchers (83.3%). Over 90% of the surveyed had a cytometer, which over 30% having multiple instruments. The survey covered satisfaction of the investigators with their resources, user and instrument operator experience, level of and access to training, access to service and service contracts and maintenance costs.

The results of this survey reveal a movement in the research community toward sophisticated research studies, indicating for better access to more advanced equipment. Inquiries about applications showed immunophenotyping and tumor diagnosis to be the unsurprising dominant techniques, and cell cycle analysis, cell proliferation showed frequent usage. Non-biomedical applications (11.9%) including microbial ecology, plant biology and biotechnology were also identified as important.

Overall, the survey showed some interesting trends. It demonstrated considerable resources both in equipment and in personnel, but with uneven distribution across countries and institutions. It also showed the increased emphasis on biomedical research and advanced clinical applications, in addition to more routine clinical analysis. The variety of scientific research described (both biomedical and biotechnological, including drug discovery and agriculture) was considerable. It also showed that, despite the best efforts of both foreign biomedical scientists and vendor community, access to instrument support, reagents and assays, training and education all remain challenging and need improvement

**2.- Academic and Corporate Initiatives**

**2.1.- International Cytometer Donations**

One way to improve cytometry access is to donate refurbished instruments to collaborating laboratories. The National Cancer Center Institute (NCCI) program under Dr. William Telford has been operating a cytometer donation program since 2002. This program has arranged the donation of over 16 flow cytometers to laboratories all over the world. This donation program was described together with the challenges of the process: gifting to the recipient instrument, restoration and shipping, navigating international customs, and supporting equipment in often remote parts of the world. Training and educational support provided after the donation is critical for success of these efforts; this is an area that ISAC traditionally excels in, and the efforts and experience of the Live Education Task Force and the ISAC Education Committee have been leveraged toward this project. One focus of the Instruments 4 Sciences Task Force will be to facilitate such equipment donations

The ethical challenges of used equipment donations for clinical use was also discussed. Clinical analysis typically demands new instrumentation still supported by the manufacturer. Dr. Alfonso Blanco (UCD Conway Institute, Ireland) discussed his clinical and educational project in Sudan as model for collaborative sites and building up the local knowledge.

The donation of second-hand instruments constitutes both legal and ethical challenges for the corporates due to international corporate policies and restrictions on importing used equipment especially in the clinical diagnostic field. However, companies are supportive of these efforts in principle, and ways that vendors can participate in this process were discussed. More interest was expressed in the donation of new equipment, particularly for clinical applications.

**2.2.- Sustainable Cytometry for Africa**

Instruments are important, but can the hosting labs use them? Support infrastructure, including good lab space, access to clean water and stable electrical system is critical to maintaining instrumentation in a useful state. High-end cytometers often place excessive demands on lab resources. Therefore, alternative systems appropriate to the region must be considered for a correct and fast diagnosis of different diseases such as malaria. Howard Shapiro presented his theory and designs for building appropriate cytometry technology for laboratory setting with limited infrastructure. In Howard Shapiro’s own words: “In the '60s, when I was in medical school, the light microscope was the primary tool for students, who did all the counts for the labs. Of red and white blood cells, segmented or stabs. We learned to use Giemsa's dye for blood smear staining but didn't see much of malaria while training. We also used Ziehl-Neelsen (Z-N) stain for tuberculosis; Though red bugs on blue can be easy to see, a slide may yield nothing but eyestrain and tedium, while colonies grow some weeks later in medium. Let Giemsa and Z-N take bows for their ages and put brighter talent on microscope stages! A multiparameter low-magnification wide-field imager (conceptually a “flowless flow cytometer”) applicable to a wide range of tasks including the diagnosis of Malaria/Tuberculosis could be affordable (production cost <US$1,000) and sustainable for resource-poor countries in Africa and elsewhere. This is increasingly becoming a multinational effort pointing toward an open-source design.”

Several cytometer manufacturers have also produced low-cost instrumentation aimed at simple clinical analysis in regions with limited resources. Many of these systems (point-of-care – POC) cytometers with simple maintenance needs but limited analytical capacity. However, recent technological advances in photonics has also provided high-capability instrumentation in smaller packages, allowing easier installation and operation in remote areas. The companies participating in this workshop presented their systems, as well as their overall strategies for providing reagent and technical support.

**2.3.- Cytometry Education in Africa**

Training and education are both critical for any research program. However, training and education are not always synonymous. While education programs should teach up to the highest levels of the field, training is often more specific to the instrumentation and analytical needs of the institution. Dr. Paul Robinson (Purdue University) emphasized this point in his description of his workshops in Africa, including an upcoming conference in Nairobi Kenya. He also encouraged the instrument and reagent manufacturers to provide support for these efforts. Dr. Blanco also described his training programs for his cytometry project in Sudan.

Each one of the four participating companies have provided a huge variety of training and education programs that they sponsor and/or organize, including a Good Laboratory Practices [GLP] program for clinical diagnostic laboratories, regional Round Tables, Hematology Standardization for Leukemia/ Lymphoma or the Flow Cytometry Continuous Educational and Regional Immunology Workshop with ISAC. The companies also provide basic instrument training; BD Biosciences, for example, is opening new training centers in the key geographic regions of Africa to provide local training without the requirement for long distance travel.

Education has been a traditional strength of ISAC, and the ISAC Education Committee, ISAC Live Education Task Force (LETF) and CYTO U all highlight this emphasis on both training and education. Close coordination between any African working group, companies and these existing ISAC committees will be critical to leverage existing experience in cytometry training.

**2.4.- Partnerships to advance clinical research and clinical trials capacity**

Different examples of global health initiative emphasizing partnerships and alliances between researchers, clinicians, corporates and academics were presented, such as the CARES Program from Beckman Coulter (2). Drs. Karen Hogg summarized a project lead by Prof. Paul Kaye (University of York, UK), a consortium of European partners from European and African partners, funded by European and Developing Countries Clinical Trials Programme, to study the immunopathology of visceral leishmaniasis across four leishmaniasis endemic countries of East Africa and a vaccine trial in Sudan. The cytometers purchased for the project and the training provided will significantly enhance research capabilities of all sites involved.

**3.- Open Discussion**

The floor was then opened for discussion. Several attendees described their own African programs and experiences. Dr. Huw (Zip) Kruger Gray shared his experiences working on a POC cytometry project in Nigeria. Logistic and bureaucratic difficulties were discussed, although it was emphasized that these issues could not be generalized to all countries. Working closely with the local governments and research communities was essential to dealing with bureaucratic obstacles. The importance of working both with the national and international societies (such as the African Academy of Sciences), international agencies (such as WHO) and established international research organizations and foundations (Wellcome Trust, USAID, Gates, Pasteur, etc.) was strongly emphasized.

Since cultural and political situations vary dramatically between different counties, it was suggested that the establishment of working groups for defined regions might help in dealing with these obstacles.

**Discussions**

The survey of African cytometry resources yielded several other interesting findings. There was a lack of knowledge about the online resources available such as the Cytometry Purdue Mailing list, the existence of the International Society for the Advancement of Cytometry (ISAC) or the Pan African Cytometry Association. The participating manufacturers all suggested that they could direct their customers to these valuable and free resources.

A significant finding from this workshop is that many African Scientists are involved in projects and collaborations with ISAC-associated scientists. The researchers hope that the workshop will yield fruitful partnerships that will spur substantial ISAC support for African investigators.

Education, service, and post-installation support, adequate infrastructures and both local and national politics are all critical issues for managing cytometry facilities in Africa. Although these problems are often difficult to solve, a team effort between academia, manufacturers, funding bodies, local authorities and the local scientific community can produce surprisingly good results.

A key outcome of the workshop was the establishment of an African Working Group that would connect both African and foreign investigators working on joint projects. A positive observation of the workshop was the large number of existing projects involving ISAC investigators and African scientists, many of which are not widely publicized. A working group will provide a clearinghouse for such efforts and will encourage future project in this area.

Another key outcome of the workshop was the official launch of the ISAC Task Force “Instruments 4 Science”. This initiative is designed to promote the provision of instruments (new or refurbished) flow cytometers to institutions and laboratories not yet able to purchase their own equipment. I4S will connect donors with recipients and will help and advice in the donation process, including legal transfer of ownership, instrument refurbishment and shipping, and importation into the recipient country. I4S will be focus on providing support not just in African groups, also to Latin-American and Caribbean countries, Eastern European countries, the Middle East, and Asian countries with economic and/or political difficulties. I4S will work closely with the Education Committee, the Live Education Task Force, and other training programs within ISAC to support and train donation recipients to help them get the most out of their equipment. I4S will also attempt to establish relationships between donors and instrument manufacturers to provide support for instrument donations and will encourage efforts to place new equipment in recipient laboratories as part of international research collaborations. I4S will also work closely with ISAC Finance Committee and Funding Task Force to explore different mechanisms for making this effort financially possible. It will also cooperate with the ISAC Education Committee and Live Education Task Force to provide cytometry training and education. Instruments 4 Science is still in the exploratory stage, and eager for participants who have experience or an interest in instrument donations and working with recipients in the developing world. Drs Blanco and Telford will spearhead I4S as co-chairs.

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2. Beckman Coulter CARES Initiative https://www.beckman.com/about-us/cares/initiative

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**Supplementary materials:**

Supplementary Information W3\_Survey\_Results and Supplementary Information WK3 \_Highlights\_Presentation

**Abbreviations Glossary**

CYTOU CytoUniversity

I4S Instruments 4 Science

ISAC International Society for the Advancement of Cytometry

GLP Good Laboratory Practices

PACA PanAfrican Cytometry Association

POC Point-of-care

Z-N Ziehl-Neelsen