

Box S1 Interviewing methods

To gain a comprehensive and holistic perspective, we interviewed 70 recognized experts and opinion leaders from different sectors in the developing world. Interviewees were selected on the basis of input from several sources: the Grand Challenges in Global Health initiative; the Ethical, Social and Cultural team; literature searches; and ‘snowball’ sampling (in which one interviewee recommends other knowledgeable individuals). Most interviews were carried out face to face (in Cameroon, Kenya, Nigeria, South Africa, China, India and Mexico). Some took place at international meetings (in Egypt, Canada and Japan). Certain interviews were not possible in person and were carried out by telephone. All interviews were audiotaped.

We asked participants to identify the key forces influencing the development and adoption of health biotechnologies in the developing world; to describe the effect of those forces on a particular technology; and to assess the ethical, social and cultural issues influencing the development of that technology. Participants were provided with relevant information before the interviews.

Interviews were semi-structured but kept flexible so that emerging issues could be pursued, enabling participants to share personal insights and/or issues raised by other interviewees.

When new concepts were no longer put forward by the participants, we stopped interviewing them (an approach known as saturation, which is the standard method for determining sample size in qualitative research).

More than 83 hours of interview data were collected. These data were coded and evaluated using content analysis. The resultant model was shown to the participants, who confirmed its face validity and content validity.

Box S2 Describing the forces in the words of participants

SCIENCE

Capacity and Infrastructure

“There’s a big disjuncture between what the needs are in these countries and where drug development or other biotechnologies are actually located and shaped.” – Wang Yu

“You can’t even begin to think about vaccines until either you’ve succeeded in delivering electricity that will run refrigerators or have solar powered refrigerators or something in the area to keep the vaccine cold.” – Anonymous participant

Collaboration

“Collaboration works better when local actors take the lead and help to define how to implement joint activities. They often have a greater stake in the success or failure of collaborative activities.” – Calestous Juma

“What we want Western participation for is to bring innovation into thinking here. Not to think for us.” – M. K. Bhan

“They [Western scientists] come with ready-made plans, and these don’t necessarily answer local questions.” – Gideon B. A. Okelo

ETHICS, SOCIETY, CULTURE

Community/Public Engagement

“You’ve got to talk to communities. There’s a danger that much of this research that is being done on technology will result in nothing because we have not understood what the community needs are.” – Olive Shisana

“Why is it that we are not able to push free vaccines, which are life saving, whereas this salesman walks in just once and he pushes his sales of soaps and commercial beverages in this remote village—how does he do it? Soap and beverages are advertised to universally arouse pleasurable feelings of freshness and joy [...] Go to a Health Centre and you see grotesque pictures of diseased and suffering victims, of crippled Polio victims, painful syringes, pot bellied undernourished children, etc. These Health Education posters are supposed to make you rush for immunization, Under-Five clinics, etc.!!” – Dara Amar

Cultural Acceptability

“You may end up with this fantastic, efficacious magic bullet but if you don’t understand some of the local culture, customs, etc., then the uptake and acceptability are low.” – Quarraisha Abdool Karim

“Technology in Africa was introduced with colonization, and what the people of this land – of this continent – were seeing is that colonial power will bring in only those technologies which were targeting natural resources – minerals or whatever – to sustain their own economies.”
– Anonymous participant on the cultural impacts of a history of exploitation

“In developing world countries you have different cultures, and what may be acceptable in the developed world is not necessarily acceptable in the developing world.”
– Niresh Bhagwandin

“In typical African culture, men are always perceived as superior, and as a result you find that women do not have a voice.” – Koleka Mlisana

FINANCE

Commercialization in low resource settings

"[Researchers] don't move [innovation] forward as an entrepreneur, because the environment is so harsh that they wouldn't be able to commercialize their ideas." – Krishna Ella, on business environments in India that fail to encourage entrepreneurship

"Individuals may actually have good ideas, but they are petrified at the thought of presenting them because they don't think that the legal framework is mature enough to protect their ideas." – Judi Wakhungu on the impacts of poor regulatory frameworks

"People like us have realized that India provides an enormous cost advantage in process and clinical drug development. We have commercialized products like insulin and monoclonal antibodies and have forced multinational pharmaceutical companies to substantially reduce their prices. Our business strategy is about developing affordable drugs for global markets" – Kiran Mazumdar-Shaw, on the benefits of developing bio-generics and new biologicals in India

Affordability

"The principle of justice demands that if the technology is found to be effective it should be made available at a cost that is affordable to the population on whom it was experimented." – Vikram Patel

"... [I]n Kenya, there is about 35%, 40% of the population living below a dollar a day, and to expect them to buy it [a new technology], they won't. It will either be the healthcare system which will have to provide, or a combination of healthcare system NGOs or WHO..." – Asad Raja

"If a particular technology is very expensive then, at the end of the day, the chance that the technology will be adopted and solve a particular problem is likely to be low." – Judi Wakhungu

POLITICS

Domestic Policy Environment

"Struggling to change the policy environment, struggling to change the legal environment to allow science to flourish...I find these are the major things that will determine...development in the third world." – Mohamed Abdullah

"If countries do not have technology procurement policies they do not get technologies into the market place, into their economies, and therefore we don't talk about diffusion in the national system." – John Mugabe

"Researchers will continue to work hard to develop and find an efficacious product...but no product will reach the people who need it if the policy makers won't support it." – Gita Ramjee

Political Will

"We can do it. Again it comes back to, I think, political will and guts. Someone has to step up there, be the champion and say come hell or high water, this is what we're going to do." – Patrick Tippoo

"What shapes the development of biotechnology in developing economies is largely leadership at the political level." – William Makgoba

TABLE S1 INTERVIEWEES PARTICIPATING IN THIS STUDY

NAME	TITLE & INSTITUTION	NAME	TITLE & INSTITUTION
Mohamed Abdullah	Aga Khan University, Nairobi, Kenya	N.K. Ganguly	Director General, Indian Council of Medical Research, New Delhi, India
Stephen Gaya Agong	Executive Director, African Academy of Sciences, Nairobi, Kenya	Mohamed Hassan	Executive Director, Academy of Sciences for Developing World, Trieste, Italy
Khalil Ahmed	Executive Director, Shantha Biotechnics Ltd., Hyderabad, India	Marian Jacobs	Dean, Faculty of Health Sciences, Univ. of Cape Town, Rondebosch, South Africa
Ademola Ajuwon	Senior Lecturer & Sub-Dean, Faculty of Public Health, University of Ibadan, Ibadan, Nigeria	Gerardo Jiménez-Sánchez	General Director National Institute of Genomic Medicine, Mexico City, Mexico
George Alleyne	Special Envoy of the Secretary General for HIV/AIDS in the Caribbean, United Nations	Calestous Juma	Director, Program on Science, Technology and Innovation, Harvard University, Cambridge, USA
Dara Amar	Professor & Chair, Dept of Community Health, St. John's Medical College, Bangalore, India	Musimbi Kanyoro	Secretary General, World YWCA, Geneva, Switzerland
Niresh Bhagwandin	Executive Manager: Strategic Research Initiatives, MRC, Cape Town, South Africa	Quarraisha Abdool Karim	Assoc. Prof. of Public Health, University of KwaZulu-Natal, Congella, South Africa
M.K. Bhan	Secretary, Department of Biotechnology, New Delhi, India	Salim Abdool Karim	Director, CAPRISA, Congella, South Africa
Mpoko Bokanga	Executive Director, African Agricultural Technology Foundation, Nairobi, Kenya	Nathaniel Khaole	Professor, Faculty of Health Sciences, Univ. of Cape Town, Mowbray, South Africa
Swami Brahmeshananda	Secretary, Ramakrishna Mission Ashrama, Chandigarh, India	Bruno Kilunga Kubata	Network Director, BioSciences Eastern and Central Africa, Nairobi, Kenya
Zhijie Chang	Professor, School of Medicine, Tsinghua University, Beijing, China	Rajesh Kumar	Professor & Chair, Dept of Community Medicine, Post Graduate Institute for Medical Education and Research, Chandigarh, India
Mingzhe Chen	Professor of Medicine, Peking University, Beijing, China	Ed Liu	Executive Director, Genome Institute of Singapore, Singapore
Mushtaque Chowdhury	Deputy Executive Director, BRAC, Dhaka, Bangladesh	William Makgoba	Vice Chancellor, University of KwaZulu-Natal, Durban, South Africa

John Clemens	Director General, International Vaccine Institute, Seoul, Republic of Korea	R.A. Mashelkar	Director General, Council of Scientific and Industrial Research, New Delhi, India
Nares Damrongchai	Executive Director, APEC Center for Technology Foresight, Bangkok, Thailand	Kiran Mazumdar-Shaw	Chair and Managing Director, Biocon Ltd., Bangalore, India
Krishna Ella	Chairman & Managing Director, Bharat Biotech Ltd., Hyderabad, India	John McDermott	Deputy Director General, Int'l Livestock Research Institute, Nairobi, Kenya
Peter Folb	Chief Specialist Scientist, Medical Research Council of South Africa, Cape Town, South Africa	Koleka Mlisana	Project Director, CAPRISA, Durban, South Africa
Farhat Moazam	Prof. & Chair, Centre of Biomedical Ethics and Culture, SIUT, Karachi, Pakistan	Olive Shisana	President & CEO, Human Sciences Research Council, Pretoria, South Africa
Villoo Morawala-Patel	Founder & CEO, Avesthagen Technologies, Bangalore, India	Fang-Lin Sun	School of Medicine, Tsinghua University, Beijing, China
Carlos Morel	Former TDR Director, Rio de Janeiro, Brazil	Xuehai Tan	CEO and President, HD Biosciences Corp. Ltd., Shanghai, China
John Mugabe	Advisor, New Partnership for Africa's Development, Pretoria, South Africa	Godfrey Tangwa	Associate Prof. of Philosophy, University of Yaounde, Yaounde, Cameroon
James Ochanda	Associate Professor in the Department of Biochemistry, University of Nairobi, and Coordinator Biotechnology Laboratory Unit., Nairobi, Kenya	Patrick Tippoo	Research & Development Manager, Biovac Institute, Cape Town, South Africa
Gideon B.A. Okelo	Professor of Medicine, University of Nairobi, Nairobi, Kenya	Cristina Torres	Coordinator, FERCAP-SIDCER, Manila, Phillipines
Onesmo ole-MoiYoi	Research Director, Int'l Centre of Insect Physiology & Ecology, Nairobi, Kenya	V. K. Vinayak	President, Biopharmaceutical R&D, Panacea Biotech Ltd., New Delhi, India
Father Sebastian Ousepparampil	Director, Catholic Health Association of India, Secunderabad, India	David Wafula	Research Fellow, African Centre for Technology Studies (ACTS), Nairobi, Kenya

Vikram Patel	Wellcome Trust Senior Clinical Research Fellow, London School of Hygiene & Tropical Medicine & Sangath, Porvorim, Goa, India	Judi Wakhungu	Executive Director, African Center for Technology Studies, Nairobi, Kenya
Adi Paterson	Group Executive, Dept. of Science & Technology, Pretoria, South Africa	David Walwyn	Group Manager, Council for Scientific & Industrial Research, Cape Town, South Africa
You-Lin Qiao	Chief & Professor, Dept of Cancer Epidemiology, Chinese Academy of Medical Sciences, Beijing, China	Florence Wambugu	CEO, Africa Harvest Biotech Foundation International, Nairobi, Kenya
Atta-ur Rahman	President, Pakistan Academy of Sciences, Islamabad, Pakistan	Carolyn Williamson	Professor, Institute of Infectious Disease, Univ. of Cape Town, Cape Town, South Africa
Asad Raja	Professor & Chair, Dept of Surgery, Aga Khan University, Nairobi, Kenya	Rosemary Wolson	Intellectual Property Manager, Council for Scientific and Industrial Research (CSIR) South Africa, Cape Town, South Africa
Rajkumar Ramesar	Professor & Head, Division of Human Genetics, University of Cape Town, Cape Town, South Africa	Lan Xue	Professor & Associate Dean, School of Public Policy and Management, Tsinghua Univ., Beijing, China
Gita Ramjee	Director, HIV Research MRC, Durban, South Africa	Huanming Yang	Professor and Director, Beijing Genomics Institute, Beijing, China
Jaime Sepulveda	Coordinator of the National Institute of Health in Mexico, Mexico City, Mexico	Wang Yu	Director, Chinese Center for Disease Control and Prevention, Beijing, China
Ismail Serageldin	Former VP of World Bank; Director, Library of Alexandria, Alexandria, Egypt	Yongyuth Yuthavong	President, Thai Academy of Science and Technology, Bangkok, Thailand
Yiming Shao	Chinese AIDS Expert, Beijing, China	Xiaomei Zhai	Executive Director, Research Centre for Bioethics, Peking Union Medical College, Beijing, China

Table S2 Participant details

		%
Region		
AFRO		49
SEARO		27
WPRO		14
AMRO		6
EMRO		4
EURO		0
Sector		
Academia		49
Government		26
Civil society		16
Industry		10
Gender		
Male		79
Female		21

Table S3 Analysis of participants' comments

Force	Number contributing to discussion (%)
Science	
Scientific capacity and infrastructure	71*
Collaboration	67
Ethics, society, and culture	
Community/public engagement	79*
Cultural acceptability	74
Finance	
Affordability	81**
Commercialization in low-resource settings	67
Politics	
Domestic policy environment	34
Political will	44

* Discussed one or both topics.

**Figure includes intellectual property and regulatory issues.