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Hassan Masum, Abdallah S. Daar, Sara Al-Bader, Ronak Shah, and Peter A. Singer

Accelerating Health Product Innovation in sub-Saharan Africa

Before the Bill and Melinda Gates Foundation began to make its extraordinary contributions, little funding was available for scientific discovery to address the major health needs of the world's billions of poor.[1] The financial stimulus of the Gates Foundation, along with investments from other foundations and governments and contributions from the private sector, has improved the situation dramatically.

Now many public-private partnerships, such as the Medicines for Malaria Venture (MMV) and the Foundation for Innovative New Diagnostics (FIND),[2] focus on product development to fill a hitherto largely empty product pipeline.

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The success of these partnerships is only now beginning to become apparent, perhaps most obviously in the fact that a malaria vaccine now seems within reach. Newer initiatives like the Grand Challenges in Global Health,[3] and delivery initiatives like Advance Market Commitments,[4] have further enhanced the pipeline of new products to address diseases of the poor.

We applaud these initiatives, believe they require increased support, and deeply hope that as many affordable and effective products as possible will emerge from the pipeline. However, now that we are beginning to see a global value chain of health innovation, the time is right to reflect on the balance between innovation in the northern and southern hemispheres. At present most of the discovery occurs in the North, for delivery in the South.

In this article, we address a core question: "How can we accelerate the science-based development of health products and services in Africa?" We answer this question by suggesting a concrete action plan, based on African voices: health convergence centers and venture funding to stimulate the development of science-based health products and services.

Before delving into the "how" of such an action plan, we want to address the "why." We see at least four good reasons for such a plan. First, as local entrepreneurs are in touch with local consumers, they know their needs and financial restrictions. Indeed, the Silicon Valley entrepreneur and inventor Bala Manian pointed out that he had to unlearn all he had learned in Silicon Valley before he could effectively innovate health products in India.[5]

Second, in the long term, dependency breeds resentment. Unless they participate actively in discovery and development, citizens of the developing world may increasingly resent being excluded from the improvements in wealth and capability that flow from innovation.

Third, local market demand is substantial and growing, and people want better or more appropriate health products and services that are not yet available locally. Local innovation can tap into this demand to create self-sustaining cycles of local development and delivery.

Finally, ingenuity knows no borders, as global firms discover when they seek to identify talent in emerging economies. While the world is beginning to tap into ingenuity in the emerging economies of India and China, ideas and talent are still being wasted in Africa, because barriers keep ideas from getting to market and few value-added jobs are available locally.

Science-based health innovation in Africa will be different from the U.S. model. U.S. biotechnology developed with massive investments of public research funds through the National Institutes of Health; venture capitalists then cherry-picked the most commercially attractive prospects. The scorecard for the industry as a whole is not compelling, although some firms have done extremely well.[6] Innovation in Africa would proceed along a very different path, perhaps more akin to the way Indian companies developed: focus initially on immediate market needs to produce revenues and then use that revenue to move up the value chain and grow by re-investing retained earnings.[7]

A question naturally arises: is an innovation-based approach more effective than simply applying existing technologies better, such as by providing more medical services and drugs? But this is a false dichotomy, as we must meet present needs and pursue future opportunities simultaneously. For example, decades ago vaccines evolved from a scientific novelty to a mainstay of global public health. Similarly, why would anyone today want to use only bed nets to fight against malaria? We should pursue both approaches: bed nets address immediate humanitarian needs, while vaccines could, in the future, eliminate the need for bed nets. This strategy should not be viewed as "either-or," but rather as constructing the near and longer-term future simultaneously.

Several high-level reports from the U.N., African Union, and other organizations have recognized the potential of the life sciences industry to address Africa's health and environmental challenges, and to channel growing indigenous scientific and entrepreneurial capacity toward innovative health products and services. Other nations—including India, China, and Brazil—have already experienced successes on this path. Surely the faster-developing and better-governed African regions can move toward joining them, especially if they focus on areas of strength and share best practices and resources among themselves. While it is not easy to approach the depth of expertise and breadth of market opportunities of India or China, a co-operating network in Africa would have the advantages of increasingly integrated regional markets, external support, and prior models to learn from (including some life science and health successes in smaller developing nations such as Cuba).

Our research in Ghana, Tanzania, and Rwanda indicates that key elements of science-based health innovation and commercialization do exist, but face a critical obstacle: the lack of linkages and skill flows between scientists, entrepreneurs, investors, and other actors. In response, our proposed network of "health convergence centers" would stimulate R&D-based health entrepreneurship, and the venture fund would invest in opportunities in the network and elsewhere. The goal is to bring together science, business, and capital into a critical mass of cross-learning players. We believe this will lead to the development of entrepreneurship and of affordable health products and services focused on local needs. Ultimately the macro-economic benefits of high-quality job creation will capture the value of indigenous innovation.

AFRICAN HEALTH CHALLENGES AND INDIGENOUS R&D

At present, no vaccines are effective against malaria, HIV, or TB. The millions of African deaths each year from these and other diseases are an economic and humanitarian disaster. Without HIV/AIDS, a Commission for Africa report suggests, the GDP of 33 African countries would have grown an extra 1.1 percent per year between 1992 and 2002.[8] The direct and indirect costs of malaria may total up to 3 percent of GDP in the malaria-endemic countries of sub-Saharan Africa, yet even this statistic understates malaria's long-run cumulative effects.[9]

But such statistics also indicate the possibility of dramatic "returns on investment" from effective health products, especially where low-cost products can treat high-prevalence diseases like malaria. Effective investments in health innovation can boost a nation's long-term productivity and economic development.

Across the continent, investments in S&T (science and technology) are increasing. Mohamed H.A. Hassan, the executive director of TWAS, the Academy of Sciences for the Developing World, describes recent progress in African scientific capacity:

> Rwanda has boosted expenditures on science to 1.6% of its gross domestic product (GDP), striving for 3% within the next 5 years. Research and development funding in South Africa is scheduled to grow to 1% of its GDP by 2009. Nigeria plans to invest $5 billion to create a national science foundation. Uganda, with a $30 million loan from the World Bank, will establish a fund for research initiatives to be selected through a nationwide merit-based competitive process. Zambia, with a $30 million loan from the African Development Bank, will offer postgraduate fellowships to train some 300 science and engineering students in its country.[10]

Hassan also ties this progress into broader advances in life sciences capacity, as well as South-South cooperation.[11] To give two other examples, the African Institute for Mathematical Sciences, in collaboration with the universities of Cambridge and Oxford, has been training a growing number of postgraduates since 2003; it aims to "expose some of the brightest people in Africa to scientific culture at the highest level and thereby help them acquire the tools to develop desperately-needed fundamental new technologies."[12] And NEPAD, the New Partnership for Africa's Development, has launched an initiative mapping the science landscape of Africa using science, technology, and innovation indicators.[13]

Investments in health R&D in Africa have already brought modest successes. The Medical Research Council (MRC) Laboratory in the Gambia, created in 1948, is the U.K.'s single largest medical research investment in a developing country, with high-quality clinical and lab research and direct provision of healthcare.[14] The Navrongo Health Research Centre in Ghana, established as a field site in 1988, has grown into an international-standard health research facility; its research has brought about significant reductions in local child mortality.[15] The TDR research and training program has been building health capacity in Africa for several decades.[16] The African Institutes of Science and Technology is a multi-campus initiative under development to build a world-class technical institution, with support from IIT-Bombay, the World Bank Institute, the International Finance Corporation, and a diaspora network of African scientists and engineers.[17]

As these examples show, increased investment in science and innovation allows African countries to grow economically and develop the capacity to take control of their own destiny.[18] In combination with improvements in governance and capacity, the UN Millennium Project report on Science, Technology, and Innovation suggests building on the limited R&D investments to date, emphasizing the value

of science-based development and of creating "…conditions that will enable developing countries to make full use of the global fund of knowledge to address development challenges."[19]

Moreover, a recent report by the African Union High-Level Panel on Modern Biotechnology looks at Pan-African innovation strategies and emphasizes the value of increasing African S&T capacity, and of linking business and life sciences:

> Regional economic integration bodies are key institutional vehicles for mobilizing, sharing and using existing scientific and technological capacities, including human and financial resources as well as physical infrastructure for biotechnology R&D and innovation. The loci of action are primarily local innovation areas which have core research and business institutions.
>
> …Local Innovation Areas [would] increase productivity and innovative capacity in individual businesses and in industry, and incubate new businesses that in their turn buttress innovation and expand the center.[20]

Similarly, the Commission for Africa report of 2005[21] recommends that the international community commit up to US $3 billion[22] over 10 years to develop centers of excellence in science and technology. But how, specifically, will the results of this science be commercialized?

AFRICAN INNOVATION: FIXING A BROKEN PIPELINE

> We need to know - what are the products that have been identified that we can really look at and improve on and then produce? In the area of malaria a lot of these herbal products make so many claims, but which of them is authentic?
>
> — Yaw Gyamfi, CEO, Dan Adams Pharmaceuticals, Ghana[23]

The shrub Cryptolepis sanguinolenta is indigenous to Africa. An aqueous extract from it has long been used by traditional medical practitioners in west and central Africa to treat several diseases including malaria. Studies have shown that its derivatives have anti-malarial properties,[24] and institutions in Ghana have studied its toxicity and marketed a tea-bag formulation domestically.[25]

But if the drug is to live up to its potential, many steps are necessary. So far, *Cryptolepis* derivatives have had only a minimal impact. Broader studies and trials are needed to determine its effectiveness and optimal dosages in order to build credibility and facilitate its export to larger markets. Production facilities and supply chains need to be built, and they must guarantee product quality to the end user. Regulatory and human resource barriers need to be overcome. Sources for the raw material must be found that can provide a steady and inexpensive supply. All these steps, in combination, represent a quagmire for the inexperienced research institution or small entrepreneur.

In Ghana, we met a professor who developed a diagnostic test for schistosomi-

asis, a parasite infection. But as long as it remains stuck in his lab, it cannot help children, just miles away, who are suffering from the disease. Meanwhile, venture capital is available, though not invested in life sciences. A good regulatory framework exists, and the health minister wants to commercialize health products. But these critical assets are not connected, and no one can get the diagnostic test from the professor's lab to the villages where it is needed.

> Our main challenge has been getting partners, especially with industry, to market our dipstick for commercial use.
>
> —Professor Kwabena Bosompem, Noguchi Memorial Institute for Medical Research, Ghana[26]

Unblocking the barriers that keep such research stuck in a lab will help realize economic and health gains. These barriers come in a range of areas, such as financing, clinical trials, intellectual property, licensing, manufacturing, delivery, and understanding motivations and markets.[27]

Similar barriers apply to inexpensive solutions that do not involve high-tech products. For example, we know of ways to innovate on pricing and systems that can better deliver health products and services. In many such cases, enabling Africa to develop its capacity requires developing good ideas into real-world solutions and then scaling these solutions up into a sustainable route to health and wealth.

With the goal of understanding these barriers and potential solutions, we are conducting research in Ghana, Tanzania, and Rwanda. A total of over one hundred in-depth interviews have been conducted with a cross-section of entrepreneurs, scientists, government officials, civil servants, local representatives of international organizations, academics, and health experts. Although this work is still in progress, we can share some early conclusions based on our analysis of the data so far.

In Ghana, we conducted an assessment and case study of innovation in the domestic health system, at the invitation of the health minister, Hon. Courage Quashigah. We interviewed 35 stakeholders from academia, government, civil society, and private industry, and subsequently analyzed these primary interviews, in combination with research and analysis of secondary sources.[28] Three key conclusions emerged:

- Many important elements of an innovation system exist. However, without more synergy and knowledge flows between companies and S&T actors, it will be hard to commercialize new health technologies.
- Innovative biomedical and health R&D show the potential to be commercialized.
- The financial incentives and resources for commercialization are currently inadequate.

In Tanzania, we conducted a case study at the invitation of Hon. Peter Msolla, the Minister of Higher Education, Science and Technology. Like Ghana, Tanzania has many key players in the health innovation value chain and significant research capacity. Again, however, the knowledge is not flowing between groups to facilitate the commercialization of new health technologies, especially between research

institutions and the private sector. Again, research remains stuck in a laboratory.

We floated the idea of convergence with the various stakeholder groups, all of whom supported the idea and identified ways that such a mechanism could overcome missing linkages and accelerate the path of innovation. One participant highlighted this enthusiasm:

> I am excited by it. I think a lot of the gaps are not real gaps but more about getting the linkages to work. For me, that kind of convergence center would be a good place to get these ideas processed, so the visions of all the stakeholders are taken into consideration. So I would look at it from the point of view of the farmer, researcher, down the line to the product, and then full commercialization with private sector – [a] bringing together of the ideas.

In Rwanda, we conducted a case study in November 2007 at the invitation of Hon. Romain Murenzi, Minister of Education, Science, Technology and Scientific Research, and our findings were similar. Our contacts showed a keen interest in a biotechnology convergence center, perhaps in the context of a potential biotechnology agency, with the convergence center adding innovation and cross-pollination by bringing health and agricultural biotechnology applications under one roof.

To further explore the viability of a platform to make these links, we organized workshops in Ghana and Tanzania, in August 2007 and December 2007 respectively. These workshops aimed to bring together the players with the knowledge and resources to collaboratively develop and implement the best solution for their country. Below, we explore the form such a platform could take, after first looking more broadly at opportunities for health commercialization in Africa.

COMMERCIALIZING HEALTH: AN OPPORTUNITY FOR A NEW APPROACH

In sub-Saharan Africa, very few places outside of South Africa move health R&D out of the lab and into a tested product. One of the exceptions is KEMRI, the Kenya Medical Research Institute, which has developed diagnostic kits for hepatitis-B and HIV, and has more in development.[29] Overall, however, little research is being translated into real world deployment:

> Scientific and technological breakthroughs do not necessarily lead to the public's access to a new product. There is no automatic, smooth transfer from laboratory to product, and then to delivery and uptake by the user.
>
> …In order to deal with the health challenges faced by Africa, individual countries need to consider innovative architectures that bring together different 'partners' from health, science, industry, finance etc who all have a part to play in ensuring a technology is developed and/or delivered.[30]

Despite the challenges, many African markets offer opportunities, especially with the emergence of regional trading blocs that increase the size of easily accessible markets. In terms of purchasing power, 20 of the 53 African nations, with a combined population of over 260 million people, have a gross national income per capita greater than that of India.[31] While heterogeneous and not as easy to serve as a single-country market of the same size, this higher-income subset of nations illustrates the potential aggregate opportunities available to a network of convergence centers.

Other data points show further opportunities:

- According to BIO Ventures for Global Health (BVGH), the potential private market demand for effective malaria vaccines is over $100 million, with a public market demand several times greater.[32] Their work also suggests significant potential markets for TB drugs, microbicides, and TB and dengue vaccines.[33]
- The WHO estimates that improved TB diagnostics could yield roughly 100 million patient evaluations per year; this adds up to a substantial market, varying across countries by per-unit pricing.[34]
- The international donor community, including foundations such as the Bill and Melinda Gates Foundation, has committed substantial ongoing funds to purchase effective health products and services through mechanisms like the Global Fund to Fight AIDS, Tuberculosis and Malaria;[35] these funds can boost the overall market demand for new, high-quality health products.
- Annual spending on health in Africa by low-income consumers is estimated at $18 billion (PPP – purchasing power parity estimate). [36]

Some success stories are already demonstrating that R&D-based health commercialization is possible in Africa. Bioclones of South Africa has been producing and marketing recombinant human erythropoietin since 1998. Several novel products are under development, including a new class of antibodies for improved vaccine production.[37]

In Ghana, LaGray Chemical Company has launched its active pharmaceutical ingredient factory, producing branded generic and licensed drugs to treat diseases of sub-Saharan Africa. The product line will include antiretrovirals, broad-spectrum antibacterials, and topical anti-infectives.[38] A to Z Textile Mills of Tanzania, Africa's largest manufacturer of malaria bed nets, is directly impregnating into the bed net fabric an insecticide that should last for up to five years. Several million nets are being produced annually, and a variety of innovative distribution channels are being explored to reduce the cost to the user.[39]

These success stories can be built on and scaled up. Many precedents for such innovative health R&D exist in emerging economies like India and China. In India, for example, Shantha Biotechnics used an innovative process and cost efficiencies to bring down the price of Hepatitis B vaccine from $15 a dose to 50 cents,[40] making it possible for India to include the vaccine in its Expanded Program on Immunization. More than half the children vaccinated in the world are immunized by products from the Serum Institute of India, a leading Indian pharmaceu-

tical manufacturer. In China, SiBiono GeneTech commercialized the world's first gene therapy product, for head and neck squamous cell carcinoma, and Shanghai United Cell Biotech is a pioneer in making oral cholera vaccines available.[41] Indeed, a growing number of health innovation success stories are emerging in other developing nations like Brazil, Jordan, Cuba, Mexico, and Malaysia.

Africa can create its own unique path to success, but it must begin. As Rwanda's president H.E Paul Kagame has said,

> We in Africa must either begin to build up our scientific and technological training capabilities or remain an impoverished appendage to the global economy...There is no reason to believe that Africa cannot achieve what others have achieved in these fields. [42]

CONVERGENCE CENTERS TO ACCELERATE HEALTH INNOVATION

Many studies have suggested that support structures, both virtual and physical, are needed to stimulate innovation and peer learning, to nurture technologies meeting societal and economic needs, and to bring these technologies to market.[43] Successful science parks, for example, have been nodes of change in China and India.

While the scale of investments and local capacity surrounding these science parks and similar locations in North America, Europe, and East Asia can be huge, the approach in Africa will differ, with investment and local capacity being thinner on the ground. We nevertheless believe and will show that a similar approach can be feasible in some African nations. A key to sustainability will be matching the monetary and time scales of investment to local capacity and finding ways to concentrate and network that capacity so that it can generate competitive outputs.

African nations are starting to invest in innovation infrastructure to achieve technological progress and boost business development. This is happening in South Africa where centers like Acorn Technologies, Cape Biotech, and the Innovation Hub have facilitated the creation of several successful companies.[44] Meanwhile, in northern Africa, the Tunis Science and Technology Park contains 35 companies, in addition to two schools and a visitor's center. Susanna Wolf quotes Nejib Abida of this park as saying, "When young engineers see all of this activity, they become less likely to pursue employment with the government, or to look abroad...We are trying to offer them space for creativity and innovation."[45]

The convergence center that we suggest represents not a revolution, but an evolution from other models such as incubators, clusters, and science parks. While an incubator is a physical location providing space and facilities to grow a small company, a cluster is a broader construct involving a range of companies and commercialization services, a strong research base, and formal and informal knowledge sharing:

> Clusters consist of co-located and linked industries, government, academia, finance and institutions for collaboration...[they] offer a fertile

> ground for innovation and upgrading of competitive advantage by firms.[46]

A convergence center can be seen as a hybrid of an incubator and a cluster, combining physical tenants with an extended virtual network beyond the physical space. It would provide both the breadth of services necessary to grow nascent scientific and entrepreneurial capacity into a fully realized cluster and the knowledge sharing and networks to accelerate this process. Such a center would act as the focal point for a combination of science, business, and capital to form novel products and services while maximizing health and economic impact. A concrete example is the MaRS center in Toronto, created with the explicit goal of realizing benefits from the wealth of life sciences research in Canada.[47] (Of course, as noted above earlier, the model for African innovation and investments would differ greatly from the U.S. or Canadian model.)

In the African context, a convergence center will include three main components. The first is infrastructure: flexible tenant space along with reliable, high-quality support services (e.g. Internet, labs, communications, electricity, conferencing). Ideally, it will be located close to a university or existing business cluster; indeed, a new breed of innovative African universities and business schools may be critical partners.[48]

The second component is the tenants and talent, selectively chosen by the center managers and investors with an eye to current competence and future potential. Anchor tenants can include established yet innovative manufacturers, pharmaceutical R&D firms, or university labs. A center could also include start-ups and smaller companies tackling new challenges, adapting a known business model or product to the local environment, or even doing contract research.

In addition to science innovators, these start-ups may be innovators in either process or price, similar to pioneers such as the Aravind Eye Care System that have used process innovation to provide quality eye care at unprecedentedly low prices.[49] As C.K. Prahalad points out, if innovation is to have an impact for low-income consumers, it must work backward, starting with what they can pay, and it must use the best technological and process ingenuity available to respond to those constraints.[50] In the African context, the simple fact of overcoming constraints on delivery, price, and localization can have as great an impact as developing a new treatment. Indeed, tenants will have many different pathways to generate health impacts. Four approaches are especially relevant:

- Develop a novel drug for a local disease from candidates identified by traditional medicine or biodiversity studies.[51]
- Make a cheaper or more effective diagnostic device that is both affordable and targeted to local diseases.
- Decrease the local cost of preventive methods, such as insecticide-impregnated bed nets for malaria prevention, vaccines, or family planning devices.[52]
- Implement novel delivery mechanisms, such as health-related micro-enterprise networks along the lines of Living Goods (Uganda), CareShops (Ghana), and

CFWShops (Kenya).[53]

A complementary set of tenants could include professionals who facilitate entrepreneurial success, including technology-transfer firms, law firms, management skills trainers, venture capitalists, and banks and other funders. Social entrepreneurs and policy groups can help both to engage local people and to improve product adoption; as professionals better understand actual local needs by working with users, the businesses that develop will be more demand-driven, and products will be better matched to local constraints. Convenience tenants like restaurants, clinics, and internet cafés can make the convergence center an enjoyable place to be, and help encourage peer learning and serendipitous interactions.

The third component is the activities and services, starting with conference facilities and a critical mass of interesting people passing through. Training programs such as bio-entrepreneurship courses or competitions to develop business plans can connect young entrepreneurs with experienced mentors and capital. Face-to-face and virtual initiatives around common problems can bootstrap learning, engage a wider community to share solutions and business opportunities, and maintain a sense of community. And inter-regional networking (both within Africa and globally) can leverage the network of health convergence centers to trade ideas, experiences, and technology.

FINANCING AND DEVELOPING THE CENTERS

How much will all this cost? The largest capital costs are for renting or building facilities and could be reduced if existing universities or labs could offer space at below-market rents. Other operating costs include salaries, equipment, entrepreneurship programs, IP (Intellectual Property) outlays, and regulatory costs and compliance at national, regional, and global levels.

Our preliminary estimates are that the total outlay over the start-up period and the first five years of operation might be on the order of $10 million per center, though this depends on many variables such as potential donations of real estate or use of existing facilities. Individual countries may choose a larger or smaller physical center and provide co-investment in cash or in kind (e.g. land, tax breaks, export support).

Since it is important to minimize fixed costs,[54] some locations might use a virtual network for an extended start-up phase, and then graduate to the full physical setup once they have grown to critical mass. In this staged approach, the initial virtual network would use low-cost rented or online venues for workshops and training, as well as networking between scientists and business-people, mentoring of start-ups, and planning the next stage of the convergence center itself. This scenario allows centers to scale up their costs over time in proportion to the opportunities they develop.

Indeed, the network of convergence centers itself should be scaled up sequentially, with earlier centers providing proof of concept and acting as learning labs for later ones. If the first physical center is put in place early in the process, and other

locations use virtual networks in spaces with low fixed costs, then all parties can learn from the implementation process and still make progress at all locations.

Partial models for this network-of-centers approach already exist in Africa. The SEDA Technologies Program supports 17 regional technology business centers in South Africa, in specific sectors including health biotechnology.[55] The African Incubator Network, which aims to develop a collaborative pan-African network of incubators and other business development service providers, is currently active in many African nations including Ghana, Kenya, Rwanda, South Africa, and Uganda.[56]

The value of such convergence centers will rise not just as they create technology, but also as they create connectivity with the right people, leading to other interactions: social innovation, mentorship, creative problem solving, and empirical testing of prototype solutions. The goal is to marry a technological focus with policy, systems, and social innovation—building capacity for both sets of partners to facilitate sustainable and innovative implementation.[57]

On the revenue side, what kind of financial income would a convergence center receive? Rental is a major component of income for successful incubators in Africa and would cover a major fraction of operating costs.[58] Other income could come from facilities and services owned and offered by the center, including rentals of conference facilities and space for retail tenants, as well as consulting and mentoring services, and other services like information technology or specialized labs. Centers could also offer training for entrepreneurs, technology managers, executive MBAs, or senior public officials, perhaps in partnership with an educational institution.

Each country will need to adapt the plan to suit its local circumstances and make many and varied decisions:

- What local strengths could be initial foci for investment?
- With which institutions could a center collaborate or share space?
- What is the right balance between virtual and physical services?
- Who are the local champions and risk takers who will make it happen?
- Should the center include health delivery businesses and microfranchisers, as complementary and critical vehicles for investment?

In Ghana, during our August 2007 workshop, we helped local professionals consider and begin to answer some of these questions. The conversations led to a specific focus on diagnostics and traditional medicine. Participants reacted positively to the idea of a health convergence center. They also recommended a task force to start the planning process, and representatives from the various ministries and stakeholders did establish one.

In Tanzania, in December 2007 we helped the Ministry of Higher Education, Science and Technology to conduct a workshop with a cross-section of stakeholders: local entrepreneurs, academics, funders from private enterprise, government officials, philanthropic foundations, and other local leaders. The active involvement of local business schools and science policy leaders led to a focus on gener-

ating a viable draft business plan for a Tanzanian center in advance and refining it based on subsequent adaptation and planning by local stakeholders.

Funding support for capital and operational costs will be critical in the early stages and may come from sources such as foundations, local governments, and the African Development Bank, as its 2007 Strategy for Higher Education, Science, and Technology includes several themes parallel to the convergence center idea.[59]

By addressing the lack of incentives to invest in the kind of infrastructure that facilitates later-stage R&D, it would be possible to structure the convergence center as a non-profit, one that will be seen as a piece of critical infrastructure. Those who want to maximize the revenue of a bridge do not raise the tolls sky-high, but instead aim only to cover its costs while maximizing the value it adds to businesses and citizens—and helping them recognize that value. Similarly, the convergence center is a bridge between science, business, and capital, and the many others who will benefit from its resulting products and services.

A VENTURE FUND FOR HEALTH INNOVATION

Remarkably, we know of almost no venture capital invested in life sciences innovation in Sub-Saharan Africa, except for the one significant fund, Bioventures, based in South Africa. This means it is extraordinarily difficult to bring ideas to market.

A key issue for any proposed fund is finding good investment opportunities. Here, a venture fund and convergence center could be symbiotic. The non-profit convergence center could act as a magnet, attracting commercializable ideas from across an entire country; for venture funders, it would be an easy entryway for seeking investment opportunities.

An African health venture fund would also address an enormous market failure. If an established company in Africa has high revenues or land that can serve as collateral, it can borrow money, but the rates are high: commercial bank loans in Ghana and Tanzania often have interest rates of 20 percent or more. But a new company with minimal revenues—like many health technology start-ups—often cannot borrow money at all.

The venture fund could respond to this problem by pulling together a combination of investors:

- *Profit-maximizing investors:* Largest and most liquid pool of investors.
- *Multiple bottom line investors*. Willing to invest funds at a lower required rate of return on capital.
- *Development banks and funds.* Investment from organizations such as the African Development Bank or IFC could bring resources, expertise, and risk mitigation for other investors.
- *Foundations.* Concessional funding can offset costs and mitigate risks, e.g. through funding investment research or operations, so investors' funds can go directly to business opportunities.

By using a variety of financing sources, each with different expectations of return, a venture fund can reduce both the risk and the effective cost of capital, thus

increasing the range of financially viable business ventures the center can take on.

Investments in start-up companies might average $1 million, spread through several stages of several hundred thousand dollars each, with the understanding that some fraction of those companies will fail at each stage.[60] Smaller investments could be useful for prototyping or early-stage trials. Larger follow-up investments will be needed to scale up operations and production for those start-up companies that succeed.

Much of the portfolio of the proposed venture fund will likely consist of seed-stage investments; these will benefit from more advice and oversight, such as that available from a new breed of companies like Acumen Fund with a multiple bottom line approach to venture capital.[61] Acumen has invested in and helped develop innovative African health product rollouts, such as A to Z's bed nets and Voxiva's use of mobile phones and related technologies for health.[62]

We suggest that investments could be spread across five countries that have macro-economic stability and a promising R&D base. In this scenario, the allocation per country might average from $5 million to $10 million, but the overall fund size could be $30 million to $50 million, allowing it to benefit from economies of scale in management expenses and investment analysis capability.[63] And in each country, the convergence center would serve as a key point of entry for the venture fund.

If an experienced multilateral institution were to co-invest, it would improve the level of capital and expertise available to the fund. For example, the International Finance Corporation (IFC) has invested in life sciences funds in India (APIDC Biotech), China (BioVeda China), and South Africa (BioVentures). It has also invested directly in well-known successes like Bharat Biotech of India and Hikma of Jordan.[64] Indeed, as of April 2006, it had invested at least $127 million in a dozen life sciences companies in emerging economies.[65]

In a promising development, the IFC in partnership with the Bill and Melinda Gates Foundation released a report in December 2007 on opportunities for private-sector approaches to health in sub-Saharan Africa.[66] The press release states that there are plans to mobilize up to $1 billion in investment and advisory services support over the 2008 – 2012 time frame, including an equity investment vehicle starting with $100 million (growing to up to $300 – $350 million over this time frame).[67] These equity investments are to be made in health care entrepreneurs and businesses, of which life sciences and innovation-based models will be a part.

RISKS AND LONG-TERM BENEFITS

> The objective of research is to find better ways of solving problems which people face. It is therefore imperative that research findings should reach end users, and in this case it is the people.
>
> — Dr. Ali Mohamed Shein, vice president of Tanzania[68]

Why invest in African countries? Private equity funds have recently found Africa to be a land of opportunity.[69] The three countries we have discussed—Ghana, Tanzania, and Rwanda—have all been experiencing substantial economic growth. But we must weigh the challenges.

One challenge is corruption. Corruption, however, is present to varying extents worldwide. Measured by the well-known Corruption Perceptions Index of Transparency International, Tanzania ranked in the same category as India, and Ghana in the same category as Mexico.[70] Yet corruption in Mexico and India, while a concern, has not deterred growing numbers of foreign investors and partners. Despite serious challenges, inspirational African voices and investment success stories are becoming easier to find.[71]

Another challenge is measuring financial potential. Do Africa's universities, labs, and early-stage companies really have enough commercializable health innovations to make productive use of the proposed venture fund and convergence center? We have shown specific examples where the answer is yes, and companies in sub-Saharan Africa are already innovating in the health product field. Given the presence of several research institutes and the lack of major venture funding outside of South Africa, it is certainly true that more research is being conducted than commercialization. How big is this gap? How much innovative research can be pulled out to the market through commercialization initiatives? These questions can only be answered by starting the process. Novel opportunities also exist to tap synergies between health and agriculture.

A final challenge is financing. Will the convergence center break even financially, and is it the best use of scarce infrastructure and development funds? We believe that by developing a solid business plan with local partners, the center's leaders can understand costs and minimize the downside risks. Another layer of independent checks will come from investors and funders in each country (for convergence centers) and for the region as a whole (for the venture fund), as they will each conduct their own due diligence before investing. The physical center will have to weigh the tradeoffs between "safe" tenants that can definitely pay the rent but do not push the envelope of health innovation, and more risky tenants who may fail but may also make enormous contributions in social or economic value in the long run.

Indeed, whatever challenges it faces, the center will help create a cadre of scientific entrepreneurs and bring them together to interact with business and financial players. In doing so, it will amplify local talents, and create a new category of relationships among those involved in science, capital, and funding. Along with the human benefits—training and empowerment, and long-term capacity develop-

ment—the core real estate asset is very likely to appreciate.[72]

What would be the long-term macro-economic and social benefits? A successful health convergence center network and venture fund will create business revenues and high-quality jobs that would not otherwise exist, particularly through the accelerated growth of small and medium-size enterprises. Investors should see these benefits as part of the return on their investment in the center. This return is captured as each center incubates and facilitates businesses, which pass on their benefits to the surrounding society.

Investors concerned with this kind of return include governments, foundations, social investors, and development banks. Any country that wants to compete in today's global economy must develop value-added businesses. Just as entrepreneurs saw no need to remain locked into land lines,[73] African countries need not remain stuck in the low-wage economy trap, forever consigned to agricultural economies.

In the category of health benefits, we showed above that poor health imposes very real economic costs on any society. Therefore, reducing this burden constitutes a real economic benefit. Consider malaria, for example: better malaria diagnostics could annually save the lives of up to 480,000 Africans, mainly children.[74] One approach to quantifying this burden economically is a recent Nigerian study that asked families how much they would be willing to pay for malaria treatment insurance; it found that, if the insurance and treatment were both effective, Nigerian households would collectively be willing to pay approximately 1.8 percent of the country's GDP to access this insurance.[75]

To the extent that a health convergence center generates positive health impacts, it will directly impact the country as a whole, including savings to the health system, fewer working days lost, higher workforce productivity, and long-term economic competitive advantage.

CONCLUSIONS

> ...there can be no peace, no security, nothing but ultimate disaster, when a few rich countries with a small minority of the world's people alone have access to the brave, and frightening, new world of technology, science, and of high material living standards, while the large majority live in deprivation and want, shut off from opportunities of full economic development; but with expectations and aspirations aroused far beyond the hope of realizing them.
>
> — Lester B. Pearson, former prime minister of Canada, on June 13, 1972[76]

Given the potential benefits, the high demand and need, and the feasibility we have demonstrated here, we see a strategic opportunity to create a network of health convergence centers linked with a sub-Saharan health venture fund. Creating this critical infrastructure will help translate indigenous talent, capital, and know-how

into positive health and economic impacts in a sustainable way.

Our proposed approach includes several key actions. Develop the convergence centers through a country-by-country process, driven by a broad-based coalition of local experts and stakeholders who create their own solutions. Pilot a first center, apply lessons to subsequent centers, and scale up if successful. Consider co-locating centers with existing institutions, to lower costs and leverage existing centers of expertise, and explore potential synergies between health and other sectors such as agriculture.

On the investment side, link the convergence centers with a venture fund, so that the centers act as opportunity generators for the fund to invest in, and the fund supports many businesses in the centers. Finally, assess the potential "deal flow" for this venture fund through research into existing health R&D that could be commercialized.

If this combination of centers and fund succeeds in the health and life sciences area, it could serve as proof of concept for an even more ambitious goal: expanding the model to include water, energy, environment, and other key technology domains. Imagine a network of implementation centers that channels funds and expertise to amplifying and facilitating local solutions, harnessing the tremendous entrepreneurial resources available into a self-sustaining improvement cycle that can tackle many other basic human needs.

A key issue is at stake here. Several African countries have invested in human capital and succeeded in creating democratic governance and stable macroeconomies. Now, will they enter the higher-value, knowledge-based sectors of the global economy? By tackling their own problems and implementing their own solutions, indigenous talent can combine with investment to create sustainable innovation capacity and positive health outcomes.

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3. A list of the 14 Grand Challenges and corresponding project details can be found at

<www.gcgh.org>.

4. From <www.vaccineamc.org>: "An Advance Market Commitment for vaccines is a financial commitment to subsidize the future purchase (up to a pre-agreed price) for a vaccine not yet available if an appropriate vaccine is developed and if it is demanded by developing countries."
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17. See <www.scidev.net/randd/subsahara/soboyejo and www.nmiscience.org/who_we_are.html>
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