DATA
IMPACTS

HOW THE DATA REVOLUTION IS MAKING A DIFFERENCE

OPEN DATA WATCH

About the Data Impacts Project

This report summarizes the lessons learned from the Data Impacts project, which explores success stories of the ongoing Data Revolution. The case studies chosen span the themes of health, agriculture and environment, cities, and humanitarian crises, and are drawn from countries all over the world. The cases examine the long and complex pathway from data to impact, focusing on the stages of data generation and collection, methodological development, data analysis, use in the policy process, and project implementation.

Key Messages

Data-driven projects are improving human and environmental welfare in countries around the world. The case studies in this report offer five lessons for increasing the impact of the data revolution:

- **Stay the course**: In the long run, data can alter political attitudes and incentives. Because time scales for deep-rooted change are unpredictable, supporters of the data revolution must be willing to stay the course, financing not only proofs of concept and pilot projects but also long-term research agendas that slowly build the evidence base in anticipation of political opportunity.

- **Analyze the politics**: In order for data projects to have a more immediate impact, their objectives must be aligned with already existing political incentives. If quick wins are the goal, investing time in a preliminary analysis of the political environment is critical.

- **Build trust**: Many different kinds of actors—public sector agencies, donors, NGOs, academic researchers, private companies—are essential in the data-to-impact process. Building trust is thus essential, especially in resolving the difficult privacy and sharing issues that come with new forms of digital data.

- **Match needs and competencies**: Non-governmental organizations and foundations can play important roles in catalyzing public sector action, especially in matching the needs of government agencies with new sources of data and innovative methodologies being developed by researchers.

- **Emphasize data use, not only data generation**: Advocates of the data revolution must ensure that data inputs are actually used in policy formulation. Beyond studying politics, this calls for a closer examination of technocratic processes and sociocultural beliefs.

Acknowledgements

Abbreviations

ATSAC	Automated Traffic Surveillance and Control System
CDC	Centers for Disease Control
CHAI	Clinton Health Access Initiative
CMAM	Community-based Management of Acute Malnutrition
CSAC	Clima y Sector Agropecuario Colombiano (Colombian Climate and Agricultural Sector)
ECX	Ethiopian Commodity Exchange
FEWS NET	Famine Early Warning Systems Network
FSNAU	Food Security and Nutrition Analysis Unit
GFT	Google Flu Trends
GFW	Global Forest Watch
GIS	Geographic Information Systems
GPS	Global Positioning System
LADOT	Los Angeles Department of Transportation
MDGs	Millennium Development Goals
MTC	Mobile Telecommunications Limited
RUTFs	Ready-to-Use Therapeutic Foods
SAM	Severe Acute Malnutrition
SDGs	Sustainable Development Goals
TFCs	Therapeutic Feeding Centers
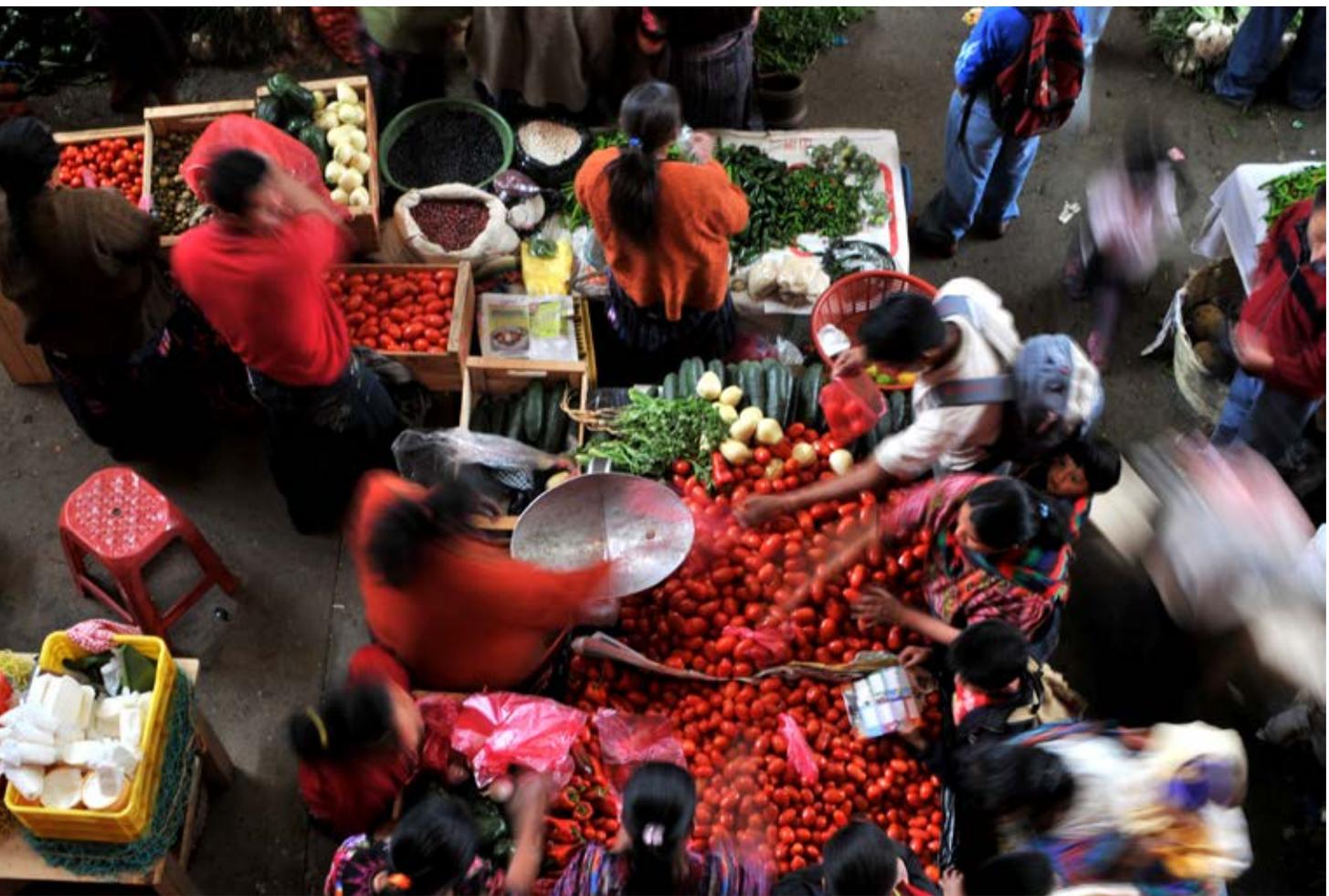
The Data Impacts Project

The Millennium Development Goals (MDGs) did more than focus the world's attention on poverty. They ignited a conversation about how we know whether good change is happening, and specifically about the role of data systems in tracking progress and giving public officials information to design effective policies. Since the launch of the MDGs in 2000, the total quantity of data in the world has grown enormously, fueled by the expansion of digital technologies. The Sustainable Development Goals (SDGs), the heir to the MDGs, will rely heavily on this deluge of information in post-2015 efforts to accelerate human development and protect environmental welfare.

In short, global optimism is high for the potential of a development data revolution. The creation of new data systems and analytical methodologies is an opportunity to emphasize important topics in development that have long merited attention—for example, the welfare of marginalized groups, the epidemiology of overlooked diseases, and the tradeoffs between economic growth and environmental sustainability. Data catalyzes debates that ultimately lead to effective policy action.

The contours of this data-to-impact process, however, are not clear. Many important questions are unanswered or only partially answered. For example, under what conditions does access to information change the beliefs of policymakers? Can the availability of data push public action closer to the interests of the poor? What is the relative importance of factors like democratization, policymaker technical experience, and administrative decentralization in determining the political demand for data?[1]

·· data catalyzes debates that lead to effective policy action ··

The purpose of the Data Impacts project is to explore these issues. The research team gathered information on 16 cases of data-driven improvements in human and environmental well-being, as well as one tragic but instructive failure wherein excellent data was available but had little policy impact. The cases, taken from countries across the world, are organized along the themes of health, agriculture and the environment, cities, and humanitarian crises. They all come from recent decades, with most focusing on successes from the past few

years. We concentrate on projects that have gone beyond simply building capacities or changing attitudes and procedures, and rather have shown substantive on-the-ground impacts.[2,3,a]

In selecting the 16 cases of success, we first reviewed 88 potential data projects that purported to have had a positive impact on human or environmental welfare. Closer investigation, however, revealed that most of these stopped well short of their goal, for a variety of reasons. In some cases, political will was lacking to support the project through difficult stages, and initially promising ideas foundered. For others, the pressures of donor and professional expectations led to artificial acceleration of project lifecycles,

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[a] Synopses of the cases, including a list of further readings, are available at www.dataimpacts.org.

weakening implementation and impact. In short, data projects failed for many reasons, but successful ones shared some common characteristics. The patterns underlying success are the focus of this report, which brings together lessons from the case studies, interviews with professionals working in the field of data for development, and a literature review on the factors that influence the data-to-impact process.

In summary, our conclusions are as follows. In the short-term, political resistance is, unsurprisingly, the most powerful reason why data inputs fail to affect policy. The data projects that were able to achieve short-term results were those that faced little political opposition, and many had strong government support from the beginning. In the longer-term, however, data can alter the costs and benefits of policy action (and inaction), and thereby transform political ideas and interests. The data initiatives that were able to achieve such results are, without exception, characterized by extraordinary endurance on the part of scientists and advocates. Researchers spent years building technical consensus in their professional communities. Champions inside government slowly created relationships with academics, non-governmental organizations, private companies, and other key players. This building of trust enabled the implementation of risky, complex projects that would not have been successful otherwise.

The results of this project unequivocally indicate that, despite formidable technical and political obstacles, data-driven change is indeed possible. In all the diverse ways demonstrated by the case studies, data is a powerful tool to create more inclusive, healthier economies and states. Project by project, the promise of the data revolution is being fulfilled.

Lessons from the Case Studies

The sections below divide our cases into two sets: those that had a relatively rapid effect on human and environmental welfare, and those that were responsible for longer-term, but often deeper, reforms.

RAPID VICTORIES

building trust: malaria elimination in Namibia

Namibia is one of the world's success stories in the fight against malaria. In 2004, over 600,000 cases of malaria were recorded in the country, a striking caseload in a population of just over two million. Seven years later, that number had dropped to around 14,000, a reduction of 98%. Eliminating malaria completely, however, is

challenging. Instead of identifying broad patterns of illness, health officers must track isolated cases and reconstruct pathways of infection. This is beyond the capability of conventional surveillance systems, and so officials at Namibia's Ministry of Health partnered with the Clinton Health Access Initiative (CHAI), researchers at the Flowminder Foundation and the University of Southampton in the United Kingdom, and the largest cell phone network provider in Namibia, Mobile Telecommunications Limited (MTC), to gather malaria data in novel ways (Case #1).

The new approach uses satellite and cell phone data together. Satellite images help researchers draw detailed maps of vegetation, population density, rainfall, and other drivers of mosquito and malaria parasite populations. These maps predict malaria risk at a very localized level. Data on the cell tower locations that receive call signals then helps to reconstruct population movement patterns. Together, the two types of data help predict where the infections originate and how they are transmitted from community to community.[4] The research allowed the Ministry of Health to use scarce resources more efficiently: in 2013, the health system distributed bednets to the 80,000 people most central to the malaria transmission cycle, a much more viable target population than the 1.2 million people living in malarious areas.

•• personal trust was critical in resolving the difficult privacy issues around cell phone data ••

Several factors contributed to the success. The Clinton Health Access Initiative made the decision to place their personnel within the Ministry of Health instead of operating separately. This helped to

build trust, which proved critical as the work moved from research to program implementation. Strong working relationships between MTC and the other parties also helped resolve some of the difficult privacy issues around the sharing of cell phone data.[5]

All of this depended on policymaker support, and fortunately political will to eliminate malaria existed at the highest levels of Namibia's government. The policy process was ready for data-informed approaches. The combination of well-established relationships and rigorous research, using methods already validated by the Flowminder and University of Southampton team in other countries, did the rest.

public sector leadership & non-governmental facilitation: urban transport cases

Two other cases in our set, both dealing with urban transportation, also illustrate the importance of public sector leadership. In 2013, the Los Angeles Department of Transportation (LADOT) completed the citywide Automated Traffic Surveillance and Control (ATSAC) system to deal with traffic congestion (Case #10). Using magnetic sensors installed at intersections, the system gathers data on vehicle build-up and adjusts the timing of traffic signals to optimize traffic flow.[6] In Seoul, the city government analyzed anonymous cell phone data from recent years to map urban movement patterns at night, and then used this information to design optimal night bus routes (Case #13). The initiative allowed the city to service 7,000 nightly riders on nine heavily trafficked routes, while cutting late night fares dramatically.[7] Both Los Angeles and Seoul recognized the potential of data to solve a pressing problem lacking obvious solutions; but the data, as groundbreaking as it was in both cases, was useful only because of the political will already present.

Non-governmental organizations can be critical in catalyzing government action, especially in connecting new forms of data and innovative analytical techniques with public sector programmatic needs. We saw this in the example of CHAI connecting Namibia's Ministry of Health with MTC and the Flowminder/University of Southampton research team. Another case is the Bill and Melinda Gates Foundation assisting Nigeria's health ministry to use geographic information systems (GIS) data to improve polio vaccination efforts in the north of the country (Case #2). The approach, which uses satellite and real-time Global Positioning System (GPS) data to track the coverage of vaccination teams, is of great benefit to the polio elimination effort, especially in isolated areas.[8]

·· even groundbreaking data needs political support to have a rapid impact ··

the economic value of data: environment and agriculture cases

Ensuring that data is valuable to government agencies is clearly important in building political support. Often, however, generating direct economic benefits for citizens can also quickly create a constituency for data systems. The Seoul night bus service, for example, resulted in an estimated redistribution of $1.2 million to poorer income groups riding the buses. Another case is the Ethiopia Commodity Exchange (ECX), which disseminates market price information to farmers across the country (Case #9). Before the ECX's launch in 2008, small farmers had little access to price data. Within

four years, trader margins had fallen by almost half, with farmers making most of the associated gains.[9,10] Yet another example is the Colombian Climate and Agricultural Sector (CSAC) partnership, which uses locally adapted climate models to make recommendations to rice growers in the country (Case #7). In 2013, CSAC saved farmers nearly $3.6 million by advising them to fallow fields before a forecasted drought.[11] In all cases, the economic gains to individuals and households helped build support to maintain or expand the projects.

politics, big data, and the speed of impact

The core activities of all of the above projects, from data collection to policy impact, took place in a relatively short time frame, usually over just a few years. One important common element in all of the cases is the alignment of political and economic incentives with the objectives of the data project. The projects teach us that if data is to have a rapid impact, such alignment *must* be present; and thus investing time in carefully examining where political opportunities exist is necessary in order to find "quick wins" for new data systems. If political will is absent, genuine reform of the status quo and consequent impact may take many years, as the next section discusses in depth.

•• to find "quick wins", invest time in examining where political opportunities exist ••

This close link between political support and the time frame of impact should also influence how we explore the potential of big data—data from cell phones, social media and other internet activity, digital transactions, and so on—for development. Big data research must begin with clear objectives and well-defined hypotheses. Open-ended exploration—data mining to identify relationships of interest rather than approaching datasets with pre-existing hypotheses in mind—is important in advancing the frontiers of data science. But we have seen through our cases that governments are less interested in exploring the abstract potential of data than they are in exploiting its ability to solve well-defined, immediate problems. If rapid impact is the goal, problem-driven studies will remain the research of greatest policy value.

exceptions to the rule? rapid changes to the status quo

We did find some exceptions to the assertion that rapid change is only possible when resistance by powerful actors is minimal. In two case studies, we found that the availability of data had relatively quick effects, but because these changes are fairly recent and incomplete, we are hesitant to draw firm conclusions.

The first case is air quality reform in Beijing (Case #8). The city is infamous for its air polution. Levels of PM2.5 particulate matter—dust, dirt, soot, and other particles less than 2.5 micrometers in diameter that enter deeply into the lungs—are especially high.[12] The deterioration of Beijing's air has been noted for quite some time, but not until recently, with the publication of real-time air quality sensor data on the internet, has the issue become politically salient. In response to increasing pressure from civil society groups and the media, the federal government and Beijing city officials launched an ambitious plan to improve air quality with a projected budget of over $400 million committed between 2013 and 2017.[13,14] Given the competing imperative of economic growth, however, it is unclear whether the relatively sudden political turnaround can be sustained.

Another example comes from the Global Forest Watch (GFW) project, which uses satellite images to track trends of deforestation, mining, and fires (Case #6). GFW imagery has been used in several instances to expose corporate malfeasance in forest management. Indonesia and Singapore, for example, rely on GFW's fire monitoring tool to track illegal burning of forests.[15,16] Another notable activist effort in Peru exposed illegal logging by United Cacao, one of the world's largest cocoa producers, and led the Peruvian government to impose sanctions against the company.[17] To date, however, United Cacao's operations in the area continue. The power of satellite imagery to audit natural resource extraction activities seems promising, but the actual impact on behavior is still uncertain.

LONGER-TERM REFORMS

John Maynard Keynes, in his classic *The General Theory of Employment, Interest and Money*, wrote of his conviction that "the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas".[18] Keynes is contrasting politics ("interests") with knowledge ("ideas"), especially knowledge obtained through social scientific inquiry. This is the optimistic spirit of the data revolution: that even entrenched political forces can be dislodged, the direction of policy altered, by the steady accumulation of reliable knowledge. We noted in the previous section the power of political support for short-term data-driven impacts; we discuss in this section the power of data for long-term erosion of political resistance, a prospect Keynes clearly thought possible.

stay the course: the case of cash transfers for humanitarian response

Until recently, the international community utilized food aid as the primary resource for humanitarian response (Case #15). This makes intuitive sense: food deficits imply food needs. The reality is more complex, however. Over the past two decades, a great deal of data has shown that, where markets are working, cash aid is often more useful. Cash allows families to decide their own priorities, which even in times of hunger include non-food items such as medicines, agricultural inputs, and so on. In addition, food aid can

depress the local agricultural economy by lowering crop prices—again, seemingly a positive development in food emergencies, but in reality quite harmful when many of the afflicted are farmers and farmworkers. Cash, in contrast, can stimulate the local and regional agricultural economy, provided the threat of inflation is confronted.[19-21]

Political resistance to food aid reform was formidable, however. This opposition mainly originated in the United States, by far the world's largest humanitarian donor. The food aid lobby was comprised

of strange bedfellows indeed: US shipping companies, NGOs, agribusiness lobbies, conservative politicians seeking to protect farmer interests, and liberals who saw criticism of food aid as a threat to the humanitarian aid system more generally.

The evidence against food aid—again, in situations where markets are working—began to mount. Data showed the huge cost of shipping food from overseas, the humanitarian consequences of logistical delays, and the harmful effects of imported grain on local agricultural production. Advocates within and outside government persisted in pushing for change, even when the debate deteriorated into political mudslinging, as it often did. In the end, the data won: many large NGOs, at significant short-term cost to themselves, as well as donor agencies in a host of European countries, have rejected the use of food aid where cash is more appropriate. The US government, for its part, has begun incremental reforms that appear unlikely to be reversed.[22-24] Progress towards a more rational international aid system has been slow and tortuous but unmistakable, propelled by the force of credible data.

•• progress towards a more effective aid system is slow but unmistakable, propelled by credible data ••

convincing the technical community: the case of child malnutrition

Governments are not the only actors that must be convinced in order for new ideas to take hold. The technical community can also present considerable resistance, as another of our case studies illustrates.

Severe acute malnutrition (SAM), also called severe wasting, is one of the most serious health issues facing preschool children worldwide (Case #16). The condition, brought about when children rapidly lose weight due to inadequate food consumption or illness that prevents the absorption and retention of nutrients, kills half a million children a year. The health of millions more is compromised, opening the door for other serious infections.[25]

•• the political moment can be hastened by a combination of high quality data and tireless champions ••

For decades, SAM was treated exclusively in hospitals or in specialized Therapeutic Feeding Centers (TFCs). There are many problems with this approach, however. Only a small percentage of severely wasted children are reached by these facilities, which are often in centralized locations away from the rural areas where most undernourished children live. Large concentrations of sick patients in hospitals and TFCs also facilitate the spread of infections deadly to children with suppressed immune systems. The burden on other family members is also

great: wasted children take weeks to recover, which means that parents must spend long stretches of time away from other children and work responsibilities.

In the early 2000s, Dr. Steve Collins, the nutritionist Kate Sadler, and the NGO Concern Worldwide began developing an alternative model to treat SAM. They noted that Ready-to-Use Therapeutic Foods (RUTFs)—candy bars and nut butters packed with nutrients to help children recover—could be used as a form of outpatient treatment for the 80% of wasted children who do not have complications. The major advantage of RUTFs is that, in contrast to the specially formulated milks used in health facilities, they do not easily spoil outside a refrigerator, enabling families to keep the foods at home and nurse sick children themselves. In addition, the team introduced a simple way of screening for SAM: bands that measure mid-upper arm circumference, with color codes denoting if a child is moderately or severely wasted. After minimal training, community members can use the bands to diagnose wasting themselves, greatly increasing the number of wasted children identified for treatment.[26]

Despite the promise of this "Community-based Management of Acute Malnutrition" (CMAM) model, the international health community was strongly resistant. The idea of treating very sick children as

outpatients challenged conventional wisdom, which called for optimal facility-based conditions. In response, Collins and others began to collect information on CMAM performance in Malawi, Ethiopia, and Sudan, eventually gathering data on 21 programs and over 23,000 children.[27] They approached governments and health agencies with the results, slowly eroding opposition to reform. By 2007, the key UN agencies responsible for global nutrition protocols were convinced, and they released a joint statement endorsing CMAM. More recent data on cost-effectiveness further bolstered the case for CMAM, and over 40 countries currently have wasting treatment guidelines with a community-based component included.

These two cases illustrate that data can be a powerful tool in overcoming opposition to meaningful reform, but also needed are reformers with tremendous endurance.[b] The truism that change comes when the political moment is ripe, not when the evidence is unequivocal, still holds; but the political moment can be hastened by a combination of credible data and skillful, tireless champions.

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[b] For further examples, see additional cases not discussed here: Case #3 on stunting reduction and Case #5 on the use of demographic and health surveys to improve women's welfare.

data is not enough: the Somalia famine of 2011

We close our investigation of cases with a stark example of failure to drive home the point that data alone is never enough. The 2011 Somalia famine killed more than a quarter million people and hundreds of thousands of children became severely malnourished (Case #17).[28] The long-term repercussions on livelihoods were devastating: livestock herds were wiped out, trade networks pulled apart, and farms abandoned as families fled the crisis.[29]

All this happened despite advance notice. Food emergencies in Somalia have been common over the past two decades, driven by a combination of internal conflict and recurrent drought. In response, the international community invested heavily in the creation of two early warning systems, the Famine Early Warning Systems Network (FEWS NET) and the Food Security and Nutrition Analysis Unit (FSNAU). These systems carry out periodic surveys

•• though data-driven change is possible, we should never expect the data-to-impact link to be automatic ••

to gather high-quality data on agricultural and livestock productivity, health and nutrition, crop prices, population movements, and other topics related to the well-being of vulnerable groups.[30]

As the 2010 winter rains and the 2011 spring rains both failed, FEWS NET and FSNAU repeatedly warned of the threat of famine. For several reasons, however, the alarm went unheeded. Al-Shabaab militants obstructed relief agencies from delivering food aid, a wide variety of political actors diverted what food aid did reach the ground, and U.S. anti-terrorism laws complicated humanitarian

logistics in militant-controlled areas. All of this together, combined with a general belief among donors that Somalia would once again narrowly escape famine, led to a reluctance to directly confront the difficulties of humanitarian response. The indecision of the international community resulted in full-blown catastrophe. Only when FEWS NET and FSNAU finally classified the crisis as a "famine" in July 2011—that is, when the official famine thresholds of malnutrition and mortality were met—did aid come pouring in. By then most of the damage had been done.[31,32]

It would be unrealistic to expect data systems to deliver higher quality, more timely, or more relevant information than did FEWS NET and FSNAU in early 2011, and yet political systems still did not respond as they should have. We saw from the other cases that data-driven change is indeed possible, but we should never expect the data-to-impact link to be automatic. In each context, advocates of the data revolution must carefully analyze the obstacles to impact, and devise strategies to maximize the possibility of thoughtful policy response.

Thinking About "Data" and "Revolution"

We close this report with some final reflections on the meanings of "data" and "revolution", words so often used that their precise definition is rarely commented upon. As we discuss below, the ambiguity in both these terms complicates the possibility for data to have an impact.

data, information, knowledge, and wisdom

Ackoff's (1989) now-famous distinctions between data, information, knowledge, and wisdom, and the 25 years of subsequent conversation on this theme in information science, are useful to consider.[33] In this view, data is raw input—signs without a legend. Nothing useful can be extracted without processing. Data placed in an immediate context—that is, imbued with enough structure that it gains the ability to answer interrogative questions (who, what, where, when, etc.) and thereby resolve uncertainty—becomes information. Knowledge

is information linked to a purpose. Knowledge goes beyond simply resolving past and present uncertainty through description; it allows broader analysis and the development of prescriptive strategies for future action. Wisdom is the most difficult to define, but usually implies some ethical component—knowledge used for virtuous action.

> •• we must think about what, beyond politics, prevents the increased flow of data from being used by well-intentioned and motivated public officials ••

These definitions, which draw from other works in the literature as much as Ackoff, are imprecise.[34-36] Even in this report, we have sometimes used "data" in the sense of "information" and sometimes as "knowledge"—but rarely to mean unstructured input, perhaps the most useful definition of "data". The important point here is that, if we are to differentiate these terms, "data" is by itself quite a narrow thing. Alone, it clearly lacks the ability to have an impact on human and environmental welfare. A longer process of contextualization, analysis, and ethical judgment is necessary. Note also that this is a broader view of the data-to-impact causal chain than comes from simply considering political context.

The implications for the data revolution are far-reaching. It is not enough to build systems that capture data or design methodologies that restructure data into useful information, although this latter is an

important and difficult challenge for emergine types of digital data. We must also consider how pre-existing purposes—not only political but also sociocultural and technocratic—shape the transformation of information into what is generally accepted as knowledge. It may also be fruitful to consider what differentiates data and information revolutions from a potential knowledge revolution—in other words, to think about what, beyond politics, prevents the increased flow of data and information from being absorbed and used by public officials who do have a clear purpose. Mistrust of data sources, opaque analytical methodologies, and a simple overload of data unweighted by importance may all play key roles here.

Practically, this means a rigorous self-reflective research agenda for the data revolution. We need rich histories of the zeros and ones, the things that are born as data and grow, in the happiest endings, to become wisdom. Narratives of both success and failure help us understand what support structures the private sector, civil society, and government can build for the data revolution.

slowing down the revolution

The novelist V.S. Naipaul once wrote of "…the flaw…[of the] very idea of revolution, that idea of a particular moment when everything changes and the world is made good, and men are made anew".[37] That same flaw, however, is what makes the concept powerful. We are energized by the possibility that change can come quickly, if only enough people believe it will.

As all of the case studies in this report illustrate, however, data systems need patient, sustained effort in order to be built well and impact policy. As the previous section argued, analysis of the factors that determine the demand for data, as well as the capacity of policymakers and program planners to absorb data, is necessary. Creating a technical consensus usually means many years of generating credible evidence, publishing peer-reviewed work, and disseminating results. Data projects often involve a multitude of actors with very different mandates — government agencies, academics, NGOs, donors, and private companies—and building trust requires patience. Actual use of new forms of data in field projects is a trial and error process, and often several implementation cycles are needed before program officers know how to best take advantage of the data. Department field offices need time to train their workers and build

·· funders must be willing to finance all stages in the long, uncertain path from data to impact ··

a data collection and storage infrastructure, even if analysis is done more centrally.

All of this means that the idea of a data "revolution" has its limits, and those limits are reached when the actual work of building an impactful data system takes place. The phrase is effective in motivating governments, international donors, and other actors to invest in the capture and production of data, and more generally to build momentum for the notion that evidence-based policymaking is the gold standard. But those same actors must be willing to do more than finance the production of data; they must be willing to finance all the other stages in the long, uncertain path from data to impact.

contextual revolution(s)

Finally, we suggest that the data revolution is better refashioned as a plural: data revolutions, a multiplicity of works that depend on local knowledge and innovative combinations of traditional and new forms of data, in contrast to the idea of a global information revolution based on a narrow set of analytical models and data types.

Two other cases illustrate well these points about contextualization and creative synthesis. The first looks at the reduction of homicides in Cali, Colombia under the leadership of Dr. Rodrigo Guerrero, who served his first term as mayor in 1993-95 and a second in 2012-14 (Case #14). Murder rates in the city had been surging upward in the early 1990s. Cali was one of the most dangerous cities in the world, and the drug trade was commonly believed to be the major cause.[38,39] Dr. Guerrero took a public health approach to the problem, empowering the police, the health department, and the local court system to collect better data on patterns of homicides. The lessons were surprising: instead of drug-related conflict, the combination of late night drinking on weekends and holidays and the availability of firearms was the primary cause of murders. The mayor enforced time-specific bans of liquor sales and firearms possession, and within three years the homicide rate had been halved. A similar epidemiological approach led to another reduction in murders during Dr. Guerrero's second term.[40]

Dr. Guerrero's approach was distinguished not by new kinds of data or even new kinds of analysis, but simply a willingness to coordinate city agencies to produce detailed, credible information, and then to base policy prescriptions on the patterns revealed by data. In other words, the revolution was contextual, patient, and more focused on precision than on novelty.

Another case shows the tension between new types of big data and traditional forms of data, but also how meaningful steps forward are possible when data types are seen as complementary and not antagonistic. The Google Flu Trends (GFT) application, which uses Google search activity to predict patterns of influenza, has received a great deal of media attention in the past several years (Case #4). However, GFT is often inaccurate, overestimating flu prevalence in the large majority of cases. Traditional surveillance reporting compiled in Centers for Disease Control (CDC) reports is more precise, although less timely than GFT. Best of all, however, is a

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combination of the two, which reduces error by over 50% compared to GFT and by 26% compared to CDC reports.[41] Overcoming the natural loyalties of different camps to their own approaches will not be easy, but triangulation of GFT and CDC data promises a better understanding of flu patterns than we have ever had.

The overall point is that this wave of data revolutions is less about a groundbreaking universal process than it is about many distinct efforts that share the characteristics of methodological broad-mindedness, precision, and patience. The grand stages of foundations and international organizations have served well to energize the revolution; what is needed now is the time, resources, and endurance to do the work well.

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