sightandlife

ANNOUNCING THE NEW *Sight and Life* STRATEGIC PLAN
page 22

DATA IN NUTRITION

Contents

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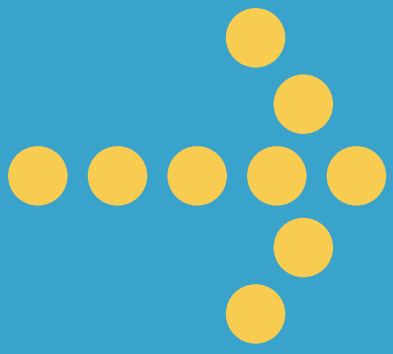

A mother engaging her children with a smartphone

The Nutrition Data Value Chain

PRIORITIZATION

Define priorities and standard indicators

CREATION & COLLECTION

Generate high-quality national and subnational data

CURATION

Aggregate, structure and report field data

ANALYSIS

Synthesize data, build analytical tools and models to derive insights

TRANSLATION & DISSEMINATION

Translate into program and policy recommendations

DECISION-MAKING

Make evidence-based decisions and implement policy

Welcome

Data is Power

Pause and look around you. Data is everywhere.

From social media and navigation maps to mobile phone apps counting calories, robots fighting climate change and governments forecasting flu outbreaks using Google, data has transformed our society in unprecedented ways. The ongoing data revolution is increasingly shaping how we create, think, collaborate and act at an individual, institutional and administrative level. In his seminal book *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*, Rob Kitchin encapsulates how data now flows as a deep and wide torrent, is low in cost, is supported by robust infrastructures and is increasingly open and accessible.[1]

While this global revolution is underway, data in nutrition lags behind. The frontline health worker on the cover of our magazine, manually inputting data into piles of registers, is an all-too-common sight in the developing world. The 2018 Global Nutrition Report affirms that "there are still vast gaps in the data available to help us better understand the nature and extent of malnutrition in all its forms. Many countries do not yet collect the necessary data to fully understand the nature of the burden of malnutrition, diet or indicators of progress."[2] As we strive to end all forms of malnutrition by 2030, there is an urgent need to harness data to track progress, hold stakeholders accountable and foster rapid collaborations.

> "As we strive to end all forms of malnutrition by 2030, there is an urgent need to harness data"

So how do we unleash the power of data to achieve better outcomes for nutrition?

1. By stimulating ideas and providing key insights that enable us to identify and frame the issues to address.

The world is reeling from the triple burden of malnutrition. One billion people consume too few calories and are hungry, at least 3 billion don't have sufficient nutrients and over 2.5 billion consume too much[3] – a compelling data point that helped reframe the entire discussion on nutrition and, subsequently, the development goals. The Millennium Development Goals (MDGs) that framed the nutrition challenge from 1990 to 2015 only in terms of "halving the proportion of people suffering from hunger"[4] were reframed to "ending not just hunger, but malnutrition in all its forms"[5] during the development of their successor, the Sustainable Development Goals (SDGs).

2. By employing robust data to inspire pledges and actions.

High-quality data providing the right inputs on the right indicators at the right time can galvanize decision-makers. Chattisgarh, a densely populated state in India, with a history of poor development indicators, performed spectacularly according to data collected by a national survey in 2016. It moved from being the state with the fourth worst proportion of stunted children to outscore the Indian average in just 10 years.[6] This stellar data point galvanized the Government of India into setting similar targets for the entire country, as part of the National Nutrition Mission, which was released in 2018.

3. By tracking the right indicators to help us understand where we should start, in what are often very complex topics.

Low birth weight (< 2,500 grams at birth) is a critical marker for babies and also for women's health and wellbeing, both before and during pregnancy. A new study by the London School of Hygiene & Tropical Medicine, World Health Organization (WHO) and UNICEF has shown that there has been minimal progress on low birth weight reduction. At this rate, the world will fall short of the WHO target of a 30% reduction in the prevalence of low birth weight between 2012 and 2025. Unfortunately, however, 47 countries (including 40 low- and middle-income countries that account for almost a quarter of all births worldwide) have insufficient data. In the face of such a data vacuum, it becomes difficult to increase accountability and improve program decisions.[7]

The pervasiveness of mobile technology in low- and middle-income countries has been a major contributor to the ongoing data revolution

4. By developing institutional capacity to drive and implement data-led decisions.

A National Evaluation Platform (NEP) was set up in response to the United Nations' call for low-income countries to improve their capabilities in evidence-based decision-making in nutrition. The aim of this platform was to improve health and nutrition outcomes in women and children by strengthening the capabilities of government institutions to use data to guide related policies and programs. In the years that followed, multi-institutional teams in Malawi, Mali, Mozambique and Tanzania – countries that are diverse geographically, linguistically and epidemiologically – built their own NEP to increase the generalizability of the tools and lessons learned from the project. A team of faculty from the Institute for International Programs at Johns Hopkins Bloomberg School of Public Health (IIP–JHU) provided tools, training and mentorship to these teams as part of a capacity-building strategy that ensured the NEP was "country-led and country-owned."[8]

These are just a few illustrative examples of the power of data for nutrition.

To take effective decisions and track progress, nutrition change agents around the globe need help answering key questions:[9]

- What data is needed, and how can that data be effectively used, across global, national and subnational institutions?
- What is the status of nutrition and food systems in particular geographies, and how can data be used to inform strategic planning and financial investment planning efforts?
- What is the progress of particular programs and initiatives, and how can data be used to help track and improve their performance?
- How can progress be measured and different parties be held accountable for systemic efforts?

The nutrition data value chain

Simplifying the relevant nutrition knowledge helps us process information and take important decisions. In this edition of our magazine, we propose an end-to-end approach and examine complex challenges and innovative responses at every step of the value chain.

The data value chain, first proposed by the Data for Decisions to Expand Nutrition Transformation (DataDENT)[10] initiative in 2017, describes the step-by-step process from identifying the data to be collected to using processed data to make evidence-based decisions. We briefly describe the links below:

- **Prioritization:** Define priorities and standard indicators.
- **Creation and Collection:** Generate high-quality national and subnational data.
- **Curation:** Aggregate, structure and report field data.
- **Analysis:** Synthesize data and build analytical tools and models to derive insights.
- **Translation and Dissemination:** Translate into program and policy recommendations.
- **Decision-Making:** Make evidence-based decisions and implement policy.

> "We propose an end-to-end approach and examine complex challenges and innovative responses at every step of the value chain"

In this issue

In this issue, we used the data value chain as the organizing framework and invited authors who are thought leaders and practitioners not just to highlight the challenges along each step of the value chain but also to offer viable solutions that are pushing the envelope.

Ellen Piwoz and Rahul Rawat, from the Gates Foundation, and Patrizia Fracassi and David Kim, from the SUN Movement Secretariat, take us through the data value chain and illustrate each link with country and global examples of progress and next steps. Gilles Bergeron from The New York Academy of Sciences lays out possibilities offered by modelling tools in *prioritizing* optimal investments in nutrition by policymakers.

Deepak Singhania and colleagues from Evidence for Policy Design (EPoD) address the *data creation and collection* component by highlighting the importance of administrative data and proposing a systemic strengthening of data collection procedures that can produce accurate and actionable information. André Laperrière and colleagues from GODAN and NNEdPro explore a method of producing and curating nutrition data that is openly available and accessible to other researchers. Roxana Elliott and colleagues from GeoPoll shed light on the power of

mobile platforms to collect data and present a practical guide for incorporating mobile methods into research.

Janosch Klemm and Saskia de Pee from the World Food Programme tackle the *data analysis* component by outlining an assessment tool that collates information from multiple sectors to help policymakers take evidence-based decisions to prevent malnutrition. Stephen Kodish from Pennsylvania State University explains how cultural domain analysis can be used by practitioners and researchers alike to generate ethnographic data for the culturally appropriate design and implementation of interventions.

Our colleague Anne Milan takes us through a practical journey of *translating* insights into powerful and visually appealing infographics. Renee Manorat and colleagues from the Results for Development Institute explain how data visualization tools could include more actionable indicators. Claudia Schauer and colleagues write about how sound technical guidance can inform decision-making for critical interventions. Jessica Fanzo, Associate Professor at Johns Hopkins University, explores the crucial but oft forgotten topic of considering ethics along the nutrition data value chain.

We also feature a range of scientific articles and field reports. In a thoughtful book review, Jonathan Steffen explores the power and also the potential dangers of big data. He also reflects on the evolution of the science of nutrition in an essay in the Nutrition in Literature series. The potential of partnerships, key lessons to be learned and the efforts required to make such partnerships work are themes explored in an account of an innovative public–private–private research partnership. This discussion reflects the consensus of GAIN, DSM, Unilever, JB Consultancy, *Sight and Life* and North-Western University, South Africa. In the Day in the Life article, we hear from innovator Shantanu Pathak and a frontline health worker, Papitha, whose day-to-day work, collecting lifesaving data, has been made simpler and more effective thanks to Shantanu's innovation.

> "We hope that the contributions in this issue will give you the motivation and knowledge to ride the data revolution wave"

We truly hope that the contributions you read in this issue will give you the motivation and knowledge to ride the data revolution wave, and that they will enhance the important work you do in freeing the world of malnutrition. Godspeed!

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With warm regards,

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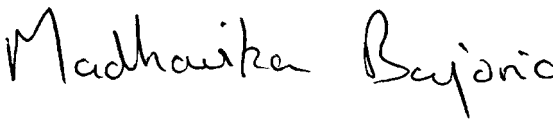

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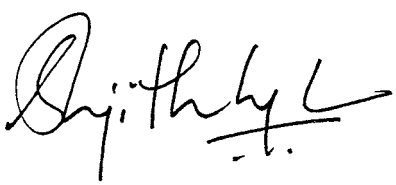

Glossary

A

Administrative data
Data collected by government agencies or other organizations, not for research purposes but for record-keeping (keeping track of registrants or transactions).

Algorithm
A set of instructions given to a computer to perform a specific task.

Artificial intelligence (AI)
The ability of a computer to perform tasks commonly associated with intelligent beings, such as the ability to reason or to learn from past experience. An example is the smart personal assistant Siri.

B

Big data
A massive volume of both structured and unstructured data that is too large to process using traditional software techniques. One of its uses is to obtain insights into consumer behavior by analyzing massive volumes of data collected from social media.

Blinded experiment
An experiment in which information is withheld from participants in order to reduce bias. A blind can be imposed on any component of an experiment, including subjects, data, etc.

Blockchain
An open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way.

C

Coding scheme
A standard that tells the user's machine which character represents which set of bytes. Without this, the machine might interpret the given bytes as a different character than intended.

D

Data landscape
An organization's data storage options, processing capabilities and analytics, as well as the applications present in its data environment.

Data value chain
The evolution of data from collection through analysis and dissemination to the final impact of data on decision-making.

Data visualization tools (DVTs)
Tools used to represent data visually in order to communicate information clearly and efficiently. Examples include statistical graphics and plots.

Database
An electronic system that allows data to be easily accessed, manipulated and updated.

Database management system (DBMS)
System software for creating and managing databases. A DBMS makes it possible for end users to create, read, update and delete data in a database, and serves as an interface between the database and end users.

I

Infographics
Graphic visual representations of information or knowledge intended to present information quickly and clearly.

Internet of things (IoT)
An extension of internet connectivity into everyday physical objects, which can then communicate with other objects over the internet, and can be remotely monitored. For example, in the future your car might instruct your house to turn on the heating and lights when you are 5 miles from home.

M

Mathematical modeling
An abstract model that uses mathematical language to describe the behavior of a system. It presents knowledge of that system in usable form.

O

Open data
Data that can be freely used, shared and built on by anyone, anywhere, for any purpose.

P

Programming
The process of designing an executable computer program for accomplishing a specific computing task. Programming involves tasks such as analysis, generating algorithms and the implementation of algorithms in a chosen programming language.

Prototype
A working example through which a new model or a new version of an existing product can be derived.

R

Real-time data
Information that is delivered immediately after collection – for example, traffic Global Positioning Systems (GPS) that show drivers what is going on around them.

S

Secondary data
Research data that has previously been gathered and can be accessed by researchers (as opposed to primary data, which is data collected directly from its source).

Software
A set of instructions that tells a computer what to do.

Prepared by Eshika Arora, Summer Intern at *Sight and Life*, with input from the editors.

Our Experience with Nutrition Data at *Sight and Life*

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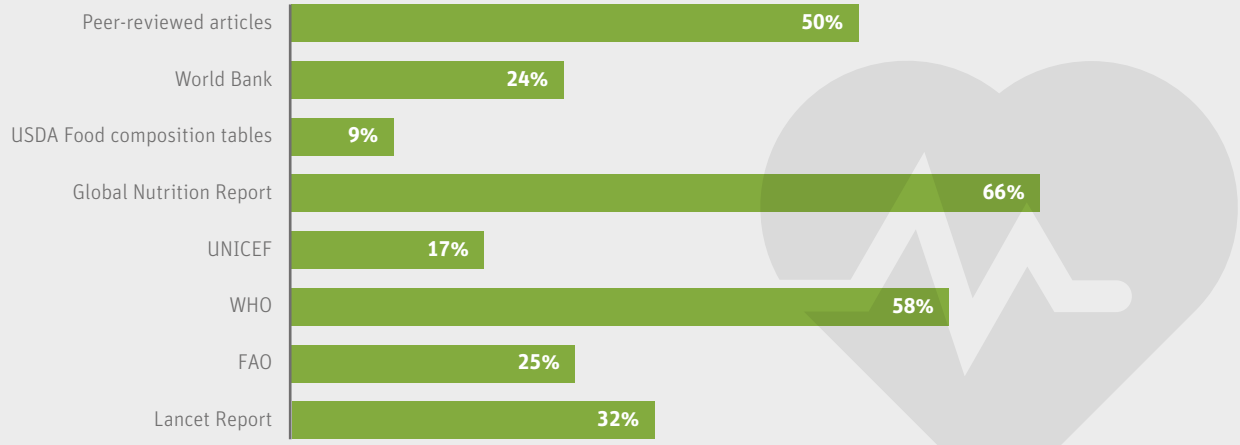
Public health nutrition data: a critical resource

Public health nutrition data is a critical resource to help us identify deep-rooted nutrition challenges and develop effective solutions to address them. While a vast number of nutrition databases seem to exist, we continue to face challenges in being able to utilize them effectively. The *Sight and Life* team therefore recently conducted a short internal survey to identify the challenges we face when working with nutrition data, with a view to finding ways to overcome them.

At *Sight and Life*, we strongly believe in the power of data to support our programs. More than 75 percent of the team are currently working on a project that involves using data on a regular basis. Projects we are currently conducting involve, for example: understanding the causes of anemia among adolescents in Indonesia; enabling smarter consumer choices through improved product labelling; using data to analyze dietary patterns among women of reproductive age; improving micronutrient intake, using mobile surveys to understand egg consumption; and turning analyzed data into easy-to-understand digital posters and infographics. These projects span all components of the entire data value chain, from defining priorities and data indicators to translating data into policies and making evidence-based decisions.

The *Sight and Life* team photographed on 6 December 2017. From left to right: Jennifer Bladt, Laura Prestel, Klaus Kraemer, Peiman Milani, Breda Gavin-Smith, Nola Martin, Eva Monterrosa, Kesso Gabrielle van Zutphen, Srujith Lingala, Kalpana Beesabathuni and Madhavika Bajoria.

FIGURE 1: Go-to sources for public health nutrition data



The cumulative percentages in this graph add up to more than 100 because team members were able to pick multiple options

Despite the data-intensive nature of our work, our survey revealed a pronounced awareness of the insufficient availability of the high-quality data necessary for making well-informed programmatic decisions: 70 percent of the team felt that the public health data required to do their work was inaccessible, collected with insufficient frequency or unusable. Simple, granular and easy-to-analyze information is missing.

> "70 percent of the team felt that the public health data necessary for their work was inaccessible, collected with insufficient frequency or unusable"

What leads to the unreliability of data? What are some workarounds?

Incompleteness of data, lack of coherence, unaggregated data and the inability to compare data across time and geographies are all factors that lead to data unreliability. When asked about the biggest pain points in the current data sources, survey respondents cited as the main challenges: incompleteness of the data presented, outdated statistics, duplication and lack of coherence, inadequate national and subnational data, and lack of validated data sources.

While these challenges may appear overwhelming, creative workarounds can be found. Our knowledge and research manager noted that if she finds an interesting reference, she doesn't hesitate to go back to the original source just to compare and cross-check findings. Our social marketing expert finds that data is often hard to interpret and visualize, especially qualitative data, and suggests using quotes to present examples of powerful insights. Other workarounds suggested by team members include talking with subject matter experts to obtain additional sources and insights, and doing one's own research when feasible and cost-effective.

What makes for good and usable data?

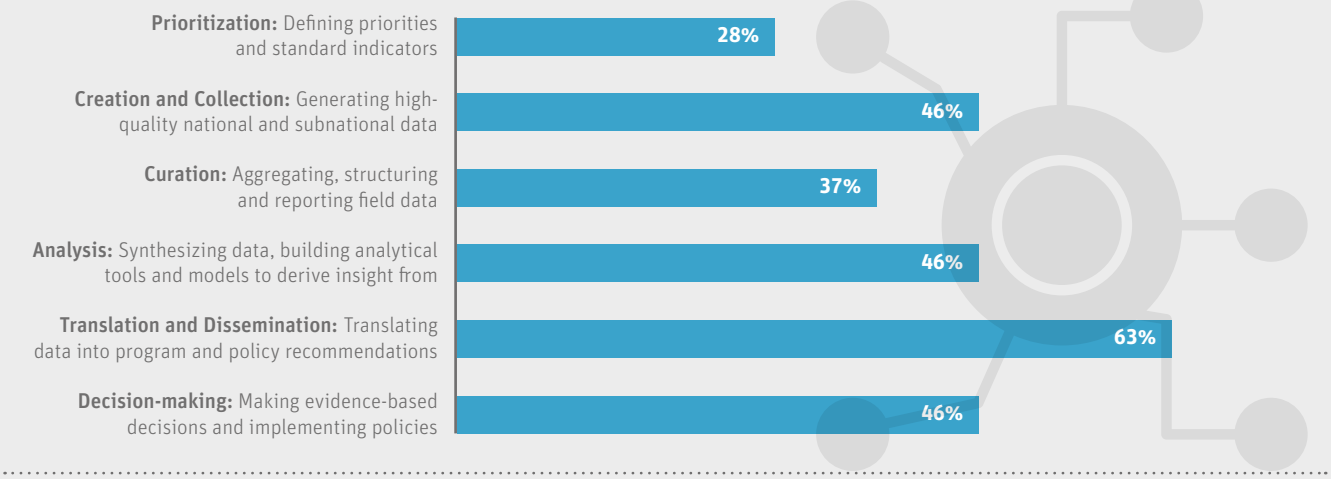
Credibility, reliability and ease of use attract users to a data source: sources such as the Global Nutrition Report, EAT–Lancet, FAO, WHO and peer-reviewed articles are the go-to sources for public health nutrition data among the team (Figure 1). We find these sources credible, comprehensive and accurate, and they provide excellent starting points when embarking on a project or study. Team members also ascribe importance to data sources such as the FAO that provide straightforward statistics and statements accompanied by graphics.

> "Sources such as the Global Nutrition Report, EAT-Lancet, FAO, WHO and peer-reviewed articles are the go-to sources for public health nutrition data"

Which components of the data value chain would we like to see more of?

When our team members were asked which components of the data value chain they would like to see more of, *data trans-*

FIGURE 2: Components of the data value chain that the *Sight and Life* team would like to see more of



The cumulative percentages in this graph add up to more than 100 because team members were able to pick multiple options

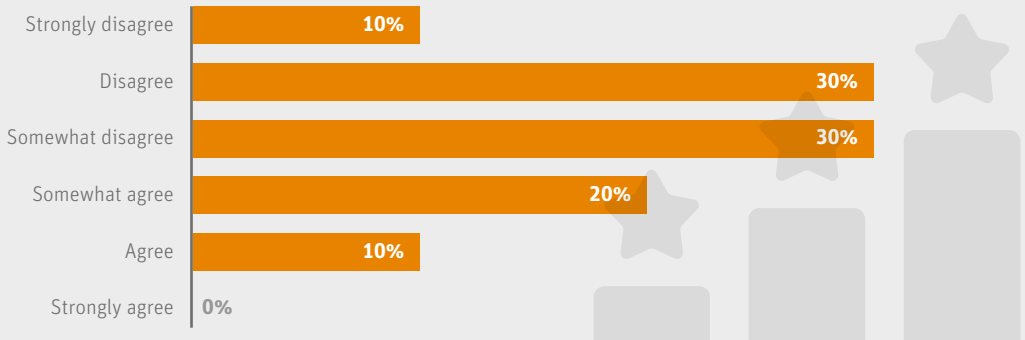
lation and dissemination polled the highest, followed closely by *data creation and collection* and *data analysis and decision-making* (Figure 2). One team member noted that she would love to see more high-quality national and subnational data collected – granular data that are regularly updated, go beyond inadequate proxies and are a true reflection of what is actually happening on the ground. Without accurate data in the first place, it becomes difficult to recommend anything that is evidence-based at a higher level. At the same time, it is imperative to make good use of the data we already have to hand. We know so much more than ever before, and yet we struggle to translate that knowledge into practice. A lot of data is still too fragmented: it needs to be turned into a digestible and actionable format. Our technology and entrepreneurship manager notes the acute need for platforms that analyze data and can help us derive crucial insights for easy dissemination.

Is the data required by our team readily available and easily accessible?

It is striking that none of our team members strongly agreed with the statement: "The data and information required to do my work is readily available and easily accessible." In fact, the internal survey reveals a general ambivalence toward data in nutrition on the part of respondents (Figure 3).

The gaps, challenges and opportunities identified by the *Sight and Life* team in this survey are explored in depth in this edition of the magazine. We hope that our analysis will provide valuable insights and stimulate constructive debate among practitioners, researchers and decision-makers in the nutrition space.

FIGURE 3: Does our team think the data necessary for their work is readily available and easily accessible?



Public health nutrition data is a critical resource to help us identify deep-rooted nutrition challenges and develop effective solutions to address them. How can we make best use of this resource going forward?

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The Nutrition Data Value Chain

Gaps and disruptive opportunities

1

PRIORITIZATION

Define priorities and standard indicators

\+ Nutrition modeling tools such as Optima Nutrition, MINIMOD, OMNI and Optifood

− Missing guidance on hierarchy of indicator categories, a dictionary of indicator definitions and operational advice, suggestions on appropriate data platforms for each category of information, recommendations on data collection frequency and examples of how data should be reported

2

CREATION & COLLECTION

Generate high-quality national and subnational data

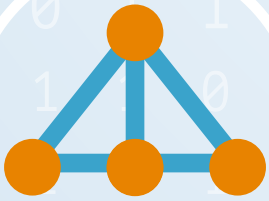
− Missing data on subgroups and populations, effective coverage of interventions and financial expenditure

\+ Strengthening administrative data, mobile platforms, open data platforms, technical guidance from credible institutions

3

CURATION

Aggregate, structure and report field data



\+ Machine learning algorithms, personalized mobile phone apps, blockchain, artificial intelligence

− Nutrition data comes from various sectors with limited systems interoperability, making curation of data and joined-up analysis challenging

\+ Disruptive opportunities

− Gaps

DECISION-MAKING

6

Make evidence-based decisions and implement policy

+ Actionable indicators, framing the right questions, institutional agenda to adapt evidence-based decisions

− Missing data, indifference to policy evidence

TRANSLATION & DISSEMINATION

5

Translate into program and policy recommendations

+ Strong theory of change, alignment of data visualization with user literacy, tools such as infographics, interactive presentations, easy-to-understand visuals

− Lack of capacity to interpret and translate data, non-aligned messages

ANALYSIS

4

Synthesize data, build analanalytical tools and models to derive insights

+ Real-time analytics and data-streaming tools, Internet of things (IoT), big data analytics

− Lack of interoperability between analytical tools, insufficient ease of use, and limited adoption by policymakers

Changing the Standard

Why multiple micronutrient supplements in pregnancy are an ethical issue

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On 9 July 1999, the United Nations Children's Fund (UNICEF), the World Health Organization (WHO) and the United Nations University (UNU) held a technical workshop at UNICEF's headquarters in New York to address widespread micronutrient deficiencies and high rates of anemia among pregnant women. Looking beyond iron and folic acid (IFA), the workshop designed a comprehensive prenatal supplement – or multiple micronutrient supplement (MMS) – that would be tested in effectiveness trials among pregnant women in low- and middle-income countries (LMICs). Thus, the United Nations International Multiple Micronutrient Antenatal Preparation – now commonly known by its acronym, UNIMMAP – was born.

The group at the workshop was, in many ways, before its time. They identified access to MMS as an inequity issue as stated in a report the group published after the workshop: "The high [micronutrient] needs of pregnancy are almost impossible to cover through dietary intake [alone] – in most industrialized countries, it is common for women to take multiple micronutrient supplements during pregnancy and lactation." And the group discussed how MMS could impact other at-risk groups, particularly adolescent girls.

They also considered the needs of the women most in need – and reflected on the information at their fingertips. The UNIMMAP formulation consisted of 1 RDA (Recommended Dietary Allowance for women aged 19–50 years during pregnancy and lactation) for 15 essential vitamins and minerals. But they correctly predicted that 1 RDA underestimated the requirements for populations in LMICs because these were based on dietary reference intakes from populations in the USA and Canada, where nutritional statuses are stronger. In April, results from the JiVitA-3 study in rural Bangladesh (the largest ever trial comparing prenatal MMS with IFA) showed that 1 RDA, while reducing risks of preterm birth, low birth weight (LBW) and stillbirth, and while improving micronutrient status, failed to eliminate deficiencies. Might 2 RDAs have had a greater effect on birth outcomes in an environment where poverty, poor diets and frequent infections prevail?

> "Malnutrition is a driver of intergenerational inequity, poverty and poor health"

The bigger picture

Malnutrition – undernutrition, overweight, obesity and micronutrient deficiencies – is a driver of intergenerational inequity, poverty and poor health. It represents a significant barrier to equitable and sustainable social and economic development, in high- and low-income countries alike. However, many women and girls lack access to essential antenatal and postnatal care services, including micronutrient supplementation. This is especially true for women living in LMICs. While 62% of pregnant women globally receive at least four antenatal care visits, in regions with the highest rates of maternal mortality – such as Sub-Saharan Africa and South Asia – only 52% and 46% of women in the respective regions receive the same services. Further coverage disparities exist between poor and rich, and rural and urban households. In South Asia and Sub-Saharan Africa, the urban–rural gap in coverage of antenatal care visits exceeds 20 percentage points in favor of urban areas, and the richest 20% of the population are more likely to receive antenatal care than poorer women. Good nutrition and equitable rights for all women are mutually reinforcing, with improved gender equality leading in turn to improved nutrition.

We see this uneven and suboptimal maternal care reflected in infant birth weight. A new study by the London School of Hygiene & Tropical Medicine (LSHTM), WHO and UNICEF finds that there has been minimal progress on reducing the number of ba-

Multiple micronutrient supplementation provides benefits to mother and child not just during pregancy but for years to come.

bies born with LBW, meaning that they weigh less than 2,500 grams at birth – a cause for alarm given that LBW increases the risk of newborn death, stunted growth, developmental delays and conditions such as heart disease and diabetes later in life. As the mother's micronutrient requirement increases during pregnancy in order to support the growth of the fetus, maternal undernutrition during pregnancy is closely linked with LBW. In 2015, 14.6% of all births worldwide, or 20.5 million babies, were born with LBW, the majority in Sub-Saharan Africa and South Asia. Urgent action is needed to get the world on track to meet global goals on LBW, and maternal nutrition must be at the center of this effort.

Time for a change

To help meet women's increased nutritional demands during pregnancy, WHO recommends IFA as the current standard of care for pregnant women – but the policy has not changed in 50 years. The most recent 2016 WHO Antenatal Care (ANC) Guidelines, however, opened a window for MMS. The guidelines counsel against the use of MMS due to "some evidence of risk, and some important gaps in evidence," but stipulate that "policymakers in populations with a high prevalence of nutritional deficiencies might consider the benefits to outweigh the disadvantages [such as cost], and may choose to give multiple micronutrient supplements that include iron and folic acid."

> "Since 2016, the scientific community has met all WHO's concerns regarding risk and evidence"

Since 2016, the scientific community has met all WHO's concerns regarding risk and evidence. Compelling scientific evidence shows that taking MMS during pregnancy reduces the risk of maternal anemia and reduces the likelihood of a child being born with LBW and too small. Anemic and underweight women benefit even more from MMS and have reduced risk of infant mortality and preterm births compared with mothers taking only IFA. Furthermore, recent research shows that MMS can reduce the gender imbalance in terms of the survival of female neonates compared with IFA supplementation alone, and that it represents an opportunity to invigorate maternal nutrition by putting women at the center of antenatal care.

The push for progress

The Women Deliver Conference (Vancouver, 3–6 June 2019) was the world's largest conference on gender equality. Through their participation, *Sight and Life* and other leading organizations are working to elevate MMS. At Women Deliver, *Sight and Life* partnered with the Children Investment Fund Foundation (CIFF), Kirk Humanitarian, 1,000 Days, Vitamin Angels and the Multiple Micronutrient Supplement Technical Advisory Group (MMS TAG) to host a side event to make the case for MMS and build support for the movement to update the global recommendations on MMS. Named Power for Mothers, this event capitalized on the gathering of global leaders, key influencers, decision-makers, civil society and donors as part of the Women Deliver Conference.

> "I firmly believe that it is unethical to further withhold MMS from pregnant women in low-resource settings"

I firmly believe that, after 20 years of research and some 20 studies and meta-analyses comparing IFA and MMS on birth outcomes, it is unethical to further withhold MMS from pregnant women in low-resource settings. The MMS TAG (to which I belong) has documented the clear scientific advantage of MMS over IFA and the safety of MMS for mothers and their children, and has shown that the provision of prenatal MMS is a cost-effective intervention. Not only is MMS cost-effective; it has also achieved cost parity with IFA.

It is no wonder that some early-riser countries with widespread micronutrient deficiencies have requested implementation research and donations of MMS for the successful replacement of IFA in their health sector. The moment has come to adapt global and national guidelines to the overwhelming evidence. Disparities in antenatal care including the provision of MMS are no longer acceptable.

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For a world free from malnutrition.

Sight and Life is a humanitarian nutrition think tank of DSM

DSM

sightandlife

Our Strategic Plan 2019–2021

Science-based and economically viable innovations to reduce malnutrition

Sight and Life informs, supports, designs, and incubates evidence-based malnutrition solutions. Originally a humanitarian aid program, our organization has continuously evolved in response to – and in anticipation of – the ever-changing nutrition landscape. This evolution necessitates regular reviews of our capabilities, capacities, objectives and strategic focus.

Following intensive reflection on how to use our unique strengths most effectively in the global battle against malnutrition, we have developed a new strategic plan for the period 2019 to 2021.

With decades of experience at the convergence of the public and private sectors, we are ideally positioned to catalyze innovative and much-needed collective action in nutrition. By leveraging the strengths and capacities of both industry and public-sector partners to address societal nutrition goals, we will deliver value to food- and nutrition-insecure populations, aiming to serve as a model for future cross-sector cooperation and impact.

Our new strategy focuses on three areas: **translating nutrition science, building public–private partnerships, and developing viable business models.**

Tackling malnutrition: a global health priority

Tackling malnutrition is a global health priority and the call for greater private-sector engagement is clear. With 3.1 million children under 5 dying from undernutrition each year, it is time for bold thinking and new approaches.

Through our new strategy, we aim to deepen our efforts to bridge the nutrition expertise and priorities of the public sector with the know-how and reach of the private sector. We will do this by identifying, informing, supporting, and inventing ways to advance global nutrition.

The global nutrition landscape

Sight and Life's strategic plan is the result of an in-depth review of our past accomplishments as well as consultations with our partners and other experts in the field.

This analysis revealed the following five trends in nutrition, as they relate to our work:

- The nutrition landscape is evolving quickly.
- Multisectoral approaches to nutrition and food systems are on the increase.
- Despite a high return on investment, nutrition funding is flat.
- Advocacy for private-sector engagement is maturing.
- The private sector has the skills and experience needed to create viable interventions.

Sight and Life occupies a unique position in the nutrition landscape. With a decades-long track record of direct engagement with the private sector, we are well positioned to promote and engage additional private-sector actors who are committed to achieving societal nutrition goals.

"The initiative [*Sight and Life*] has evolved to meet the changing needs of the world in which it operates, demonstrating considerable creativity and flexibility along the way"

Prof. Alfred Sommer, Dean Emeritus,
Johns Hopkins Bloomberg School of Public Health

A new strategic focus

Sight and Life's refreshed strategy will deliver unique value to the nutrition community and to food- and nutrition-insecure populations by focusing our work in the following three areas:

1. Translating nutrition science so that programs, policies, and participants are informed and effective. *Sight and Life* creates and translates science primarily through technical assistance and communications tools such as *Sight and Life* magazine, presentations, and journal articles.

2. Building public–private partnerships, an underutilized mechanism in nutrition, which can accelerate the private sector's engagement and maximize the impact of both the private and the public sector. *Sight and Life* has a history of creating and supporting successful public–private partnerships and facilitating policy conversations.

3. Developing viable business models that are profitable or sustainably subsidized and increase the availability and desirability of nutritious foods. Using consumer insights and unique approaches to both demand and supply, *Sight and Life* creates business models that will be viable in the long run.

The implementation of these strategic themes will strengthen our collective impact by harnessing the power of public–private partnerships and innovative business models to develop new science-based solutions.

Our vision

A world free from malnutrition.

Our mission

To innovate in nutrition towards eradicating malnutrition in women of childbearing age and their children, and so improve the lives of the world's most vulnerable populations.

Our values

- Science, purpose and (com)passion.
- Integrity and excellence.
- Leadership and innovation.
- Collaboration and interdisciplinarity.
- Continuous improvement and humility.

Working towards a world free from malnutrition

Through our new strategic plan, we recognize these trends as opportunities where *Sight and Life* can leverage our expertise, experience, and relational capital to achieve greater impact in our research and programs.

Guided by an understanding of the current nutrition landscape, we will pursue our mission by pushing boundaries, promoting science-based solutions, brokering impactful partnerships, and, ultimately, working towards a world free from malnutrition.

We look forward to partnering with you to make our vision a reality: A world free from malnutrition.

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science Research-based evidence

The Tswaka Study

A journey into an innovative public–private–private research partnership

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Key messages

- This is a report on the learnings gathered by a partnership established to perform a complex study: the Tswaka Nutrition Intervention study.
- The study was a community-based randomized controlled trial carried out in North West province, South Africa, on the efficacy of two small-quantity lipid-based complementary food supplements provided to children aged 6–12 months.
- The Tswaka study was completed in 2015 and its results have been recently published.[1]

> This report summarizes the key lessons learned and discusses what it takes to make such partnerships work. The key lessons appear on pp. 28–29.

This is a report on the learnings gathered by a unique partnership, consisting of two private-sector partners, one NGO and an academic partner, established to perform a complex study: the Tswaka Nutrition Intervention study.

The study was a community-based randomized controlled trial carried out in North West province, South Africa, on the efficacy of two small-quantity lipid-based complementary food supplements provided to children aged 6–12 months. The Tswaka study – which means 'mixing' in the local Setswana language, referring to the fact that the supplement should be mixed into home-cooked food – was completed in 2015, and its results have recently been published.[1]

The journey embarked on in 2010 presented many challenges before it was successfully completed following eight years of effort. This report summarizes the key lessons learned and discusses what it takes to make such partnerships work. We hope that our experiences and insights will be of value to others entering into partnerships in the nutrition space. In the end, our joint success came down to the three Ps: Personal relationships and trust, Perseverance and determination, and the Passion to make this project a success.

Inception: aligning motivations to create a single concept

In 2010, an NGO (GAIN) and a private-sector partner (Unilever) joined forces as a Funding Consortium to facilitate a research project investigating a novel fortified complementary food supplement. For the detailed design and execution of the intervention study, it was decided that an Academic Research Partner would be selected via a call for proposals.

One of the children participating in the Tswaka Study has her weight taken as part of the bimonthly anthropometric measurement process

The motivation for the study was different for each of the partners in the Funding Consortium. While GAIN was interested in working with private-sector partners on product formulation and demonstration of the feasibility of a market-based approach, Unilever was interested in testing the efficacy of such a product before considering an innovation project on the feasibility of a market-based approach.

Unilever wanted to collaborate with GAIN on this research because GAIN was considered a trusted intermediary between Unilever and the Academic Research Partner. Initial discussions between Unilever and GAIN, however, identified a potential conflict of interest if GAIN were to work on a study assessing the efficacy of a product from just one private-sector partner.

To address this issue, a second private partner, DSM, was invited to join the partnership. DSM wished to demonstrate efficacy for a similar product formulation that contained certain extra ingredients with additional benefits for growth and development. Despite their different motivations, the three partners recognized the benefits of sharing their complementary expertise as well as sharing the research costs within the framework of an NGO/private-partner Funding Consortium.

To align the different motivations into one achievable goal acceptable to all three partners took some time. There were discussions about the requisite levels of transparency and openness and about the dynamics driving the choices and decisions required for a successful partnership. To avoid potential complications and to keep the study to a manageable size and acceptable cost levels, it was designed in such a way that the sample size would not allow direct comparison between the two products.

> "The more organizations you have to involve, the more important it is to have regular, open communication"[2]

While these initial discussions were still ongoing, and prior to DSM joining the partnership, GAIN and Unilever had already developed a call for proposals based on an initial concept note, and an independent expert committee was formed to select the Academic Research Partner to perform the study.

North-West University, South Africa, won the bid in partnership with the South African Medical Research Council ('the research team') and started to work on a full proposal, which had to be adapted into a three-arm design when the second private partner, DSM, joined the Funding Consortium.

Simultaneously, contract negotiations had started. The idea was that GAIN would act as the official study sponsor, and also as an intermediary between the private-sector sponsors and the research team. Therefore, two contracts had to be aligned and agreed upon: one bilateral grant agreement between GAIN and the research team, and one trilateral agreement between GAIN and the two private-sector partners (the Funding Consortium), who each contributed one-third of the research costs.

Issues concerning intellectual property (IP) rights for data and for products, as well as publication and dissemination clearance procedures, had to be discussed at senior management level in all the partner organizations. The entire contract negotiations took more than a year and were eventually concluded in 2011.

Preparation phase: managing risks and building trust

The preparation phase turned out to be the most delicate phase of the entire process. There were no products ready yet, and negotiations started between the two private-sector partners with the aim of creating a single joint development process for the study products. A joint development process was thought to be beneficial because this would allow for blinding of the two intervention arms by having two products comparable in taste and appearance, albeit with different compositions. As product development and product ingredient formulations are among a company's most valued IP, it took some time for the two private partners to agree on a joint development agreement (JDA). When an issue occurred during the actual production of one of the study products, however, the private-sector partners decided to terminate the JDA and to continue further scale-up and production independently of one another.

In March 2013, the acceptability study among mothers and children with the first product samples started in South Africa. The acceptability study yielded positive results but also revealed some mild side effects, assessed as being unrelated to the intervention products as such.[3] Meanwhile, however, within the private-sector partners, changes in leadership and company strategies had taken place, leading to a revised assessment of the potential reputational risk for all partners involved in this community-based trial among very young and vulnerable children in a disadvantaged population.

To better manage and control these risks, it was initially decided to hire an independent monitor to remotely review the quality of the study execution. In addition, a Safety Monitoring Board (SMB) was established to monitor adverse effects and identify any potential causal relationships to study participation or test product. In addition, an independent study physician was hired to train and support the research team as and when needed. The study monitoring was further upscaled by hiring an independent Contract Research Organization (CRO) to ensure the quality and safety of the study by monitoring the implementation of the study on site and for data management on site.

There was a clear need to balance the risk exposure of all parties involved. Whereas the private partners wished to implement processes such as monitoring, a centralized database and extensive medical supervision and reporting, the research team wished to make sure that its credibility as an independent academic team would not be jeopardized.

Having an intermediate party in the form of GAIN turned out to be critical, ensuring effective communication between the research team and the private-sector partners and coordinating negotiations about the changing needs of both the research team and the Funding Consortium.

In addition, a site visit by the Funding Consortium helped to provide a more realistic view of the circumstances at the study site and to improve understanding of the practical dilemmas the research team faced in day-to-day management of a community-driven study of this size in this setting. It also further strengthened trust between the responsible individuals within each of the partner organizations. Due to these personal relationships and a shared commitment to succeed, it was possible to commence data collection in the fall of 2013.

Data collection: trust and transparency

While scaling-up of the production of the study product and negotiations on the involvement of the CRO were still ongoing, research staff had already been hired, and mobilization in the community for recruitment had already taken place. By the time the research team was in a position to start enrolling infants into the study, the children of mothers initially mobilized had aged over the 6 months (+ 2 weeks) enrollment criterion, with the result that they had to be excluded from participation. This caused distrust within the community, and the research team had to step up its efforts to restore confidence in the study. At the same time, the CRO, which was familiar with Phase III pharma studies, had to get used to the complexity, uncertainty and changing conditions in which community-based nutrition interventions are carried out.

Anyone experienced in conducting trials with vulnerable populations in disadvantaged communities knows that unexpected challenges are the rule rather than the exception. Continuous communication with the community members is necessary to engage all individuals involved in the partnership. The Tswaka research team had to deal with rumors and distrust within the community, while at the same time trying to explain all this to the representatives of the funding partners, some of whom had limited experience of working in these difficult settings and with this age group. GAIN played a central role in channeling initial bilateral discussions toward more central discussions throughout the project, which helped to build trust at every level.

The study site visit by the sponsors was crucial in improving understanding between the partners. Investments were made in keeping the momentum from the site visit with the community and the field workers. To keep the onsite research team motivated, extra training opportunities were offered by the funding partners.

> "The fact that there was a signed obligation between the partners meant we had to move forward and could not withdraw"

The renewed confidence within the partnership allowed for more open discussions on the issues of sponsor involvement and authorship. The dilemma was whether the growing involvement of the study sponsors in the various stages of study implementation needed to be made transparent in the publication of the study results at the level of coauthorship. For the research team, sponsor authorship was considered to reduce the independence of the individual scientists involved, and there was a realistic fear that it would also affect the credibility of the study results.[4,5]

There did not seem to be a perfect solution. When industry sponsors are not included as coauthors, this can be construed as an attempt to disguise their involvement. When they are included as authors, however, this may raise questions as to their influence on the interpretation of findings. In recent years, there has been increased recognition that stricter rules may help safeguard the independence and credibility of public–private research partnerships.[5] In the current partnership, this issue was addressed by all partners agreeing on a joint author and sponsor contribution statement, according to the international criteria for authorship. It was explicitly agreed that, while results would be discussed with all partners, the Academic Principal Investigator had full responsibility to decide on the final interpretation and dissemination of the study's results.

Data collection for the Tswaka study was completed in July 2015. Once the final statistical plan had been agreed and all descriptive statistics had been completed, a blind-review meeting was organized at the study site in November 2015. In this meeting, with all funding partners and the CRO present, data was presented and agreed prior to locking the database and de-blinding the study.

Post-data collection phase

Data management of a large study such as the Tswaka study is complex and also prone to delays for various reasons. In this case, one reason was the decision to outsource data management to a CRO with rigorous quality standards.

The rigorous and extensive data quality and data transfer steps for the collection of data on adverse events and morbidity required by the CRO's data management system slowed the research team's speed of response. To overcome this, the research team had ended up keeping its own records. In consequence, two independent databases on morbidity were kept. Given the size of the study, within a vulnerable age group, many mild adverse events occurred, making discrepancies in morbidity data almost inevitable. Having two datasets on morbidity provided the opportunity to address and counter-check some of these discrepancies. However, this caused additional delays, as data analysis could only start after the two databases had been checked for inconsistencies and combined into a single, locked database. These delays put pressure on the availability of allocated statistical support staff.

In May 2016, almost a year after completion of data collection, the databases were locked, and study codes were unblinded. The de-blinded dataset was only accessible to the research team and not to the funding partners throughout data analyses and the reporting process, to further ensure the integrity of scientific interpretation by the Academic Principal Investigator. The preliminary results of the Tswaka study were presented at the Micronutrient Forum global conference in Cancún, Mexico, in October 2016. The discussions about the interpretation of the study findings – probably the most sensitive part of any industry-sponsored research – took place following the predefined disclosure statements. The Academic Principal Investigator's final interpretation and wording of the conclusion were fully endorsed.

> "Things change often within a business environment – what is a challenge and an interest today may be different tomorrow. Priorities and people change."

All discussions, mostly academic in nature, were documented for full transparency, while the final manuscript was shared with the industry partners for clearance without further editing rights.

With the Tswaka study project and funding coming to an official end, the remainder of the work to be done (final statistical analyses, final report writing and manuscript preparation) became dependent on the personal time and commitment of the Funding Consortium team involved. This was not a problem, as the team was determined to bring this project to a successful completion. And so it happened.

Issues to be managed

Setting up a new type of public–private nutrition research partnership can be challenging, as many issues need to be managed along the way.

Real and perceived risks in areas such as safety, conflict of interests, project management, reputation and scientific independence need to be identified from the start of a partnership and managed carefully – something that requires commitment and flexibility from all partners. On the other hand, such partnerships offer unique opportunities for the different partners that cannot be realized individually. The private-sector partners, for example, had the opportunity to carry out studies on a shared costs basis and to enjoy access to scientific expertise, study teams, study environments and key experts with in-depth knowledge of the local context. The research team benefited from access to quality study product development, as well as tolling capabilities, access to quality monitoring services, and scientific nutrient knowledge, besides receiving appropriate funding. For both parties, learning from each other's expertise and developing awareness of each other's strengths and weaknesses increased mutual understanding and will be a benefit in the case of future collaborations. Last but not least, private–public partnerships can contribute to the education of a new generation of scientists with experience in dealing with these types of partnerships. In this particular project, for instance, three PhD students were involved.

Conclusions

The influence of industry funding on the perceived credibility of nutrition research is currently under debate,[4] and some guiding principles for how to manage industry funding of food and nutrition research have been proposed.[5] The Tswaka study research partnership showed that these public–private research partnerships can be successful if managed carefully and transparently. Personal commitment, trust, perseverance, passion and patience were among the key success factors. Some of the main learnings from this partnership, which may inform future research partnerships, are summarized below.

Lessons learned

1. Establishing alignment between multiple partners involves managing tensions between objectives and agendas. It takes time, it should be transparent and it should clearly identify how the respective partners' priorities will be managed.
2. Having a clearly defined, achievable and shared public health goal is important for a successful public–private partnership.[5]

3. When a consortium is being established, it is essential to have all required knowledge and expertise represented in the team and all roles and responsibilities clearly defined before commencing the study.

4. Full transparency is required from the start regarding the status of negotiations between funding partners, as well as regarding product development, to allow realistic deadline setting by the research team.

5. For research projects that involve a high reputational risk for the sponsor and/or the research team, having an independent third partner (a 'coordinator') can be helpful. The coordinator can align the academic and private sector, and can communicate regularly and directly with all consortium partners, in an effort to make best use of industry involvement (e.g., optimizing study and product quality) and to minimize direct industry involvement in the execution of the study and direct interactions with researchers.

6. Accepting industry funding involves dealing with different priorities and comes at a cost for researchers: perceived and real conflict of interests, and perceived and real reputational risks, will need to be managed; lines of communication will need to be kept open; and all roles and responsibilities will need to be clarified and agreed upon up front in well-documented author and sponsorship involvement statements, preferably before contracts are signed. Throughout the project, excellent communication is required between all partners, facilitated by the coordinator.

7. Within organizations, strategies and leadership change all the time, making it difficult to rely on continuous leadership and project ownership for a multiple-year research project. Champions within the various organizations are essential to push the project forward and bridge the different internal needs with academic needs.

8. Unexpected issues will arise and cause delays and additional expenses, as in every complex project – something all partners need to deal with. Having an independent coordinator is again helpful for aligning partners and managing expectations.

9. Building personal relationships early in the project (e.g., by visits to the study sites and face-to-face meetings between partners) is important for creating trust, mutual understanding and commitment.

Six voices say what they are most proud of having achieved through the Tswaka Study Research Partnership

VOICE 1

"We developed a very difficult product specially designed for older infants, and we achieved it with so many partners."

VOICE 2

"We completed an extraordinarily complex process to implement what we thought was a straightforward idea. We have done great research and established the groundwork for a more systematic approach for organizations to work together."

VOICE 3

"We have learned a great deal for our organizations regarding partnerships, and also for ourselves personally. We can do things better in future, but we achieved our goal in the end."

VOICE 4

"I estimate that I spent more than 9 weeks in conversations to keep this study going – but we have done it, and many from the community and research team have had opportunities as a result of it."

VOICE 5

"We have shown that these products are beneficial – that is important for children."

VOICE 6

"We managed to complete a unique PPP, and we overcame enormous hurdles through everyone's commitment and without jeopardizing our relationships."

Disclosure statement

Authors' roles

Saskia JM Osendarp: Consultant, Young Child Nutrition and Partnership at GAIN

Cornelius M Smuts: Academic Principal Investigator of the study

Klaus Kraemer: Managing Director of *Sight and Life* Foundation, a Swiss foundation funded partially by DSM

Maaike J Bruins: Study Coordinator and Senior Scientist Nutrition at DSM

Leon GJ Frenken: Project Leader at Unilever

Dominic Schofield: President of GAIN

Jane Badham: Managing Director at JB Consultancy, consultant in end-of-project evaluation

Cornelius M Smuts received traveling support from Unilever, DSM and *Sight and Life*.

Saskia JM Osendarp is a consultant to GAIN and was working on this partnership for Unilever R&D from 2010 to 2011 before starting as a consultant with GAIN.

GAIN was the sponsor of the study and is a non-profit organization working in micronutrient nutrition.

Maaike J Bruins is employed by DSM Nutritional Products, a supplier of vitamins, carotenoids, and omega-3 and -6 nutritional lipids.

Leon GJ Frenken is employed by Unilever R&D, Vlaardingen, the Netherlands.

DSM and **Unilever** were co-funders of the study and provided the test products free of charge. None of the other researchers has any conflict of interest.

This research was supported by GAIN, DSM and Unilever. Interpretation of data was jointly discussed among the Principal Investigator of the study (Cornelius M Smuts), sponsor (Saskia JM Osendarp) and co-funders (Maaike J Bruins and Leon GJ Frenken); however, final decisions on interpretation and dissemination of results rested with the Academic Principal Investigator of the study (Cornelius M Smuts).

The responsibilities of the sponsor and co-funders in this project are as follows:

1) During preparation

GAIN and Unilever developed the initial study idea and followed this with a Request for Proposals.

GAIN, DSM and Unilever reviewed, commented and approved the study proposal.

DSM and Unilever developed, produced, shipped and ensured the quality of the study products.

2) During data collection

The Academic Principal Investigator (API) was responsible for data collection. GAIN, DSM and Unilever monitored the quality of data collection throughout the study via an independent study-monitoring agency and via regular phone and face-to-face meetings throughout the data collection process.

3) During data analysis and interpretation of results

The API was responsible for data analysis.

The final interpretation of data was jointly discussed among API, sponsor and co-funders. However, final decisions on the interpretation and dissemination of results rested with the API.

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Preschool Child Vitamin A Deficiency Prevention

A strategic crossroads

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Key messages

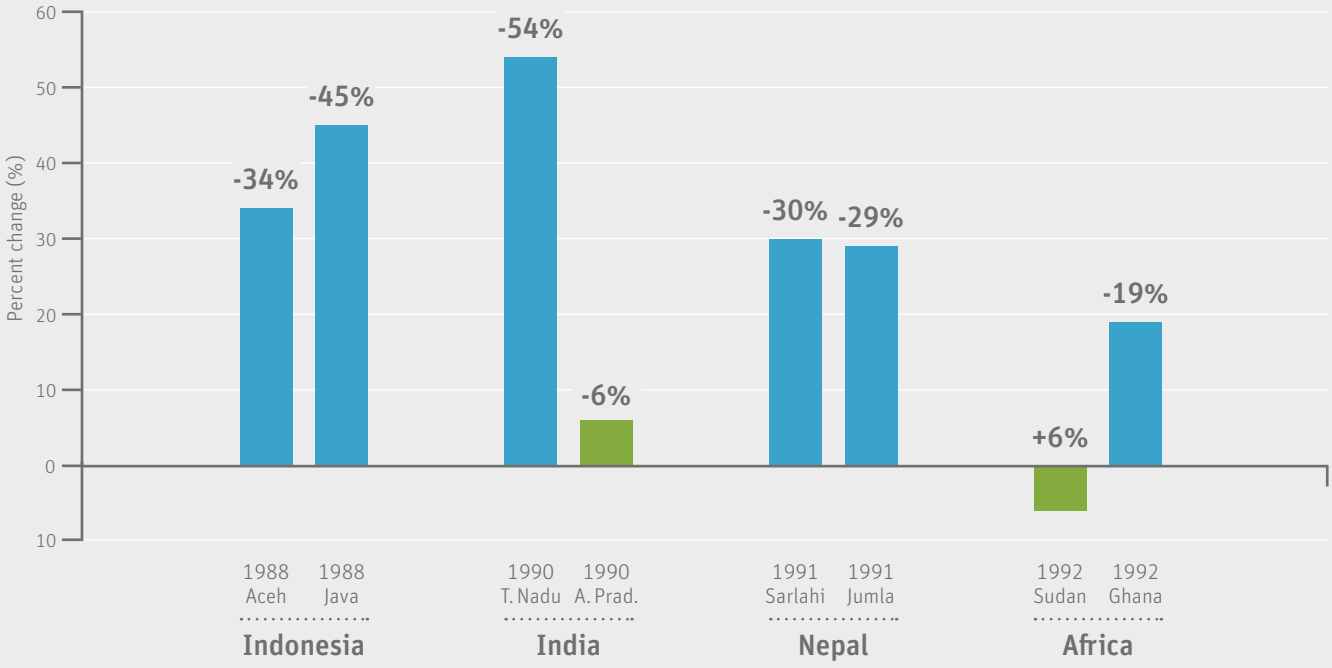
- Childhood vitamin A deficiency (VAD) is a major facet of hidden hunger, with 80 million deficient preschoolers in Africa and Southern Asia alone.
- Multiple strategies exist to prevent VAD, including periodic, high-dose vitamin A supplementation (VAS), food fortification, dietary change and biofortification.
- VAS prevents xerophthalmia, blindness, child mortality and hearing loss, but does not normalize serum retinol, which is only achievable by diet.
- While new, inexpensive measures of vitamin A status are needed, serum retinol remains an interpretable, valid and comparable indicator for population use.
- VAS can be curtailed once fewer than 10% of children (with 95% confidence) are vitamin-A-deficient, and evidence supports improved dietary intake of vitamin A in target populations.

A century after its discovery, vitamin A remains a nutrient of intense biomolecular, developmental and curative interest, and there has been a persistent public health focus over the past 50 years to assess and prevent its deficiency and health consequences in the low-to-middle-income world. Deficiency arises from a diet chronically lacking food sources of preformed vitamin A (e.g., breast milk in infancy, animal and fish liver [and oils], whole-fat dairy products and egg) or provitamin A carotenoids (e.g., dark green leafy vegetables and yellow-orange fruits, vegetables and tubers).[1] A diverse diet that provides adequate amounts of vitamin A and its carotenoid precursors is also one that generally meets nutritional sufficiency and promotes health.[2]

> "A century after its discovery, vitamin A remains a nutrient of intense interest"

Public health strategies for preventing vitamin A deficiency (VAD) include efforts to enhance food systems through the fortification of foods with vitamin A and biofortification with provitamin A carotenoids,[3] as well as horticultural, and dairy and fish farming initiatives,[4] coupled with nutrition education and behavior change communication that can expand dietary diversity.[1] Alongside a wide range of food-based and dietary approaches, periodic provision of a large (200,000 IU) dose of vitamin A has become a major, if conceptually interim, approach to protecting preschool-age children from VAD and its health consequences.[5] Suggested by Professor Donald McLaren as a biologically feasible approach to build liver stores and prevent xerophthalmia, and tested shortly thereafter in India in the 1960s,[6] semi-annual vitamin A supplementation (VAS) has evolved over the past five decades into a strategy that, today, is implemented globally.[7] While this approach is not without its limitations[8] and critics,[9] this essay argues for sustained childhood VAS to prevent vitamin A deficiency disorders (VADD) until high-risk countries demonstrate a low prevalence of deficiency, together with corroborative evidence of dietary adequacy, at which point a shift in preventive strategies will be justifiable and

FIGURE 1: Changes in preschool child mortality from population-based vitamin A intervention trials conducted in South Asia and Sub-Saharan Africa in the 1980s and 1990s



Among eight, original, population-based vitamin A intervention trials conducted in South Asia and Sub-Saharan Africa in the 1980s and 1990s, six reported significant 19% to 54% reductions in preschool child mortality (blue bars) while two trials reported no significant effects on mortality (green bars)[1]

safe. Although fortification, biofortification and food diversification strategies are making progress toward raising vitamin A intakes across regions, the lack of reliable data on the prevalence of VAD in most countries[7,11] is concealing their impact and hampering progress. There remains an urgent need for rapid, valid and inexpensive assessment methods that comparably reflect distributions of serum retinol < 0.70 µmol/L, which remains the most widely used and understood indicator and cutoff for classifying population risk of VAD.[10–12]

> "There remains an urgent need for rapid, valid and inexpensive assessment methods that comparably reflect distributions of serum retinol"

Vitamin A deficiency disorders and their response to interventions

Depleted vitamin A nutriture affects a plethora of host defense, hormonal, growth and homeostatic mechanisms that protect phenotypic development, growth, function and survival.[13] VADD comprise "health and physiological consequences attributable to VAD, whether clinically evident (xerophthalmia, anemia, growth retardation, increased infectious morbidity and mortality) or not (impaired iron mobilization, disturbed cellular differentiation and depressed immune response)."[12] VADD can be distilled to consequences of public health importance that respond in whole or in part to vitamin A interventions. In children, VADD include xerophthalmia, involving night blindness, Bitot's spots and corneal disease (xerosis and keratomalacia),[14] anemia, severity of infectious diseases, and consequent mortality,[1] and can include hearing loss following severe middle ear infections.[15] All likely coexist in areas of endemic VAD without adequate prophylaxis.

Xerophthalmia responds to the direct provision of vitamin A treatment.[1,14] Twice-annual, high-dose VAS (200,000 IU > 12 mo, 100,000 IU 6–11 mo) reaching ~85% or more of preschoolers virtually eliminates blinding keratomalacia as a public health concern[16] and reduces the prevalence of night blindness or Bitot's spots by ~60% or more.[1,17] Few new trials exist, but generally effectiveness declines markedly as coverage lapses, with little effect on prevalence to be expected below 25% coverage.[5] Fortification of one or more commonly eaten food items can

raise vitamin A status,[18–20] which should also prevent xerophthalmia. While not subjected to trials, epidemiological studies have revealed consistent, dose-responsive, protective associations against xerophthalmia through more frequent breastfeeding[21,22] and intakes of dark green leaves, orange-yellow fruits, vegetables and tubers, egg and dairy products.[1,23,24]

Preschool child mortality is reduced by vitamin A interventions, which is likely achieved by attenuating the severity of certain infectious diseases in undernourished populations. Original population-based, controlled, efficacy trials in Southern Asia and Africa revealed ~0% to 54% reductions in preschool child mortality, providing average reductions via meta-analyses of 23% to 34%, depending on the inclusion criteria,[1,25] when children received vitamin A as a 4–6-monthly high dose,[1,26,27] a weekly low dose (15,000 IU)[28] or a daily fraction of a recommended dietary amount via fortification of a food item[29] (**Figure 1**). Since 2000, a program evaluation in India[30] and a trial in Guinea-Bissau[31] have reported nonsignificant reductions of 4% and 13%, respectively, in preschool child mortality with VAS, but these lower estimates may have been due, in part, to difficulties faced in study design, implementation[30,32] and in preventing controls from receiving vitamin A during a concurrent national VAS program.[31]

> "Supporting the all-cause effect on child mortality is evidence that VAS reduces the fatality of measles"

Supporting the all-cause effect on child mortality is evidence that VAS reduces the fatality of measles, first shown in London in 1931[33] and in several trials a half-century later.[1,25] While increased measles vaccination will reduce this impact of vitamin A, VAS can still lower complication rates and case fatality where measles vaccine coverage falters,[34,35] suggesting a need for caution about prematurely desisting VAS amidst a current resurgence of measles in many areas of the world. WHO also continues to globally recommend VAS as a treatment for measles.[36] Other potentially fatal childhood infectious illnesses that are likely attenuated in severity by vitamin A include diarrhea and dysentery[1,37] and *falciparum* malaria.[38] Correspondingly, VAS has been found to reduce frequencies of early childhood clinic sick visits and hospitalizations as proxies for the severity of illness,[27] although high-dose vitamin A has lessened neither the severity nor the risk of fatality from early childhood pneumonia.[39] It is interesting to note that hospitalized, malnourished children with severe respiratory or diarrheal morbidity have been shown to respond more favorably to a low, daily dose than to a single large bolus of vitamin A,[40] similar to the response seen for child mortality following smaller weekly[28] or daily[29] intakes of vitamin A.

Otitis media, a leading cause of childhood hearing loss, is associated with VAD.[41] Experimental vitamin A depletion exacerbates tympanic membrane damage from middle ear infection, which heals more quickly with vitamin A treatment.[42] In children with acute measles, vitamin A has reduced the risk of otitis media.[43] In Nepal, adolescents who, as preschoolers, developed one or more episodes of purulent ear infection while receiving 4-monthly VAS during a community trial[26] were 42% less likely to be hearing-impaired than early childhood placebo-recipient peers who also had episode(s) of ear discharge.[15] As nearly 20% of children experienced at least one preschool episode of ear discharge, among whom ~20% of control recipients were hearing-impaired, the findings suggest that preschool VAS, beyond impacting xerophthalmia and mortality, can avert 15 cases of permanent hearing loss per 1,000 children per year of age.

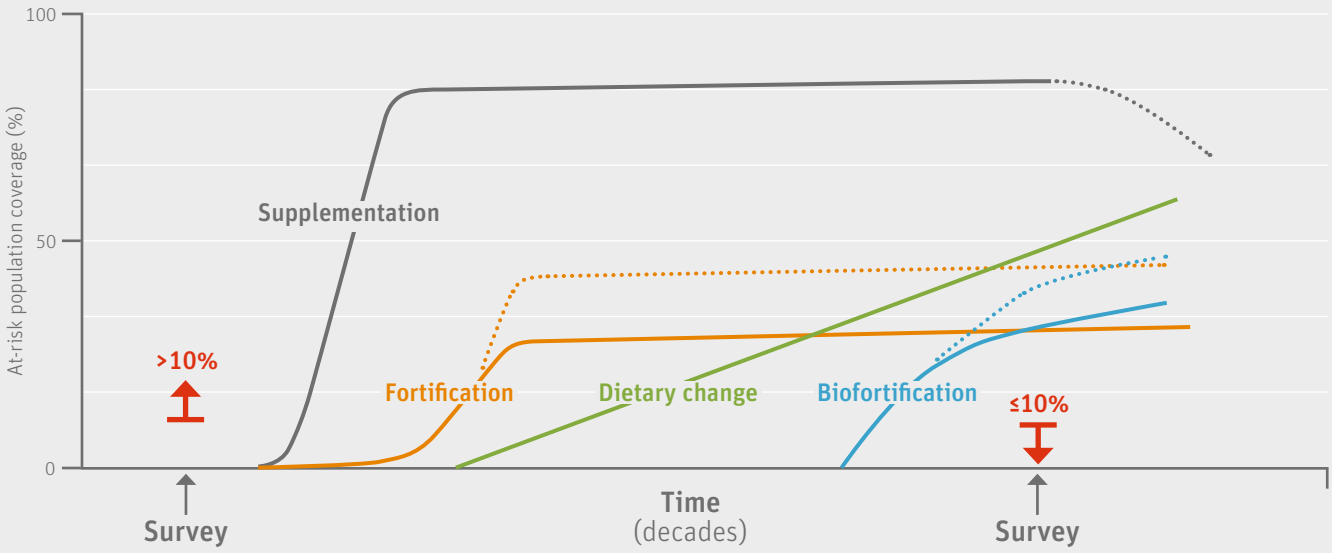
A vast literature reveals the pleiotropic roles of vitamin A, through its metabolites, in regulating innate and adaptive, mucosal/local and systemic, auto- and paracrine to hormonal aspects of immune defense.[1,44,45] These effects on elements of the immune system help to explain the diverse but generally favorable effects of vitamin A in reducing infectious morbidity in populations that are marginal to deficient in vitamin A status.

Vitamin A deficiency and its response to interventions

The vitamin A status of populations is most often evaluated by assaying serum retinol, or its binding protein, among a cache of other methods.[8,46] Serum retinol concentrations below 0.70 µmol/L (20 µg/dL) typically define deficient status,[11] which often reflects combined nutritional and inflammatory stresses that are useful to partition[46] in order to understand different causes and estimate possible responses to interventions. VAD and inflammation are, however, also inseparable, in that infection can increase vitamin A losses[47] and, experimentally, VAD itself is pro-inflammatory.[48] Regardless, hyporetinolemia has been estimated to affect 45%–50% of preschoolers throughout Southern Asia and Sub-Saharan Africa for the past three decades,[10] suggesting there are ~80 million vitamin-A-deficient preschool-age children in these two regions alone.

Vitamin A interventions may exert different effects on serum retinol. Underway for more than four decades,[5] vitamin A supplements are being distributed semi-annually to preschool-age children in 82 countries.[7] While effective in reducing VADD, for poorly understood reasons a 6-monthly pulse of vitamin A only transiently raises serum retinol concentrations or reduces deficiency by this indicator.[8] As a consequence, a serum retinol distribution should not be expected to exhibit a long-term rise following VAS or be used to evaluate this intervention. Rather, target population coverage is the prima facie indicator of performance

FIGURE 2: Complementary vitamin A interventions



Following a survey reporting VAD (serum retinol < 0.70 µmol/L) of > 10% in preschool children (**first red line**), a problem of moderate or worse public health significance,[11] interventions are launched: periodic VAS for rapid, sustainable control of VADD (**grey line**), with other strategies gradually implemented: **(a)** fortifying one (**orange line**) or more (**dotted orange line**) foods reaching target markets; **(b)** achieving dietary changes (**green line**) by agricultural, market, subsidy and behavior change approaches; and **(c)** biofortifying one (**blue line**) or more (**dotted blue line**) staple crops with provitamin A carotenoids. As combined approaches increase dietary vitamin A, and a follow-up survey (**second red line**) shows a low prevalence of VAD (< 5%[8] or upper 95% confidence limit < 10%), VAS can be withdrawn (**dotted grey line**).

and public health impact, an inference that has been supported by occasional national evaluations that have revealed high-coverage VAS programs to reduce xerophthalmia[49] and mortality.[50]

Dietary approaches – such as fortifying commonly consumed food items to deliver a significant fraction (e.g., ~⅓) of the Recommended Dietary Allowance as preformed vitamin A – reduce the risks of VADD, reflected by lowered child mortality,[29] and raise serum retinol over the long term,[18–20] thereby sustainably reducing VAD. Feeding children dark green leaves and other vegetable, tuber and fruit sources of carotenoids will raise serum retinol from deficiency although, alone, not fully normalize status.[1] Biofortifying staple crops with provitamin A carotenoids will likely also prevent deficiency, reduce VADD[51,52] and increase serum carotenoids, although only slightly further improve vitamin A nutriture[53] due to the complex determinants of carotenoid bioavailability.[54] Nevertheless, a dietary safety net against VAD can generally be assured with an assorted diet offering adequate preformed vitamin A esters and provitamin A carotenoids.

Choice of interventions to prevent vitamin A deficiency and its deficiency disorders

Countries have at hand an increasing portfolio of strategies to adopt for preventing VAD, depending on its extent and severity, the urgency to avert health consequences, dietary cultures, food system capabilities and economic resources. Figure 2 provides a conceptual diagram of how preventive strategies of supplementation, fortification and biofortification and approaches to improve dietary diversity can unfold over time. Countries can exist anywhere on this continuum. Supplementation can be scaled up relatively quickly to effectively control VADD (reduce xerophthalmia, severe morbidity and mortality) in young children, but it fails to address dietary causes, sustainably improve status or address other target groups (e.g., neonates, school-age children, adolescents and women of reproductive age). While there are vocal calls for countries to shift away from VAS,[9] any decision to do so should be based on representative data of improved vitamin A status, together with supportive evidence of increased vitamin A intakes that explain the improved status. Effective dietary strategies should both prevent VADD and, with some fraction of retinol equivalency derived from preformed vitamin A (animal or fortified) food sources, normalize serum retinol distributions. Periodic surveys that measure serum retinol as the primary indicator of status can provide comparable and interpretable indicator data. It has been suggested that a basis for shifting from VAS can exist where national surveys have found the prevalence of deficiency (serum retinol < 0.70 µmol/L) among preschoolers to be < 5%.[8]

Alternatively, the estimated prevalence should have an upper 95% confidence limit < 10%, the WHO minimum prevalence for a moderate or worse public health problem.[11] Either way, there should also be supportive evidence of increased availability and intakes of foods rich in vitamin A and carotenoid by children and mothers in vulnerable regions.[8]

> "While there are vocal calls for countries to shift away from VAS, any decision to do so should be based on representative data"

Conclusions

VAD remains a major burden in impoverished societies, with significant health consequences. Globally, VAD prevention is at a crossroads of achievement, capability and multisectoral commitment. As with all micronutrient deficiencies, mapping VAD to at-risk target populations is hindered by infrequent assessment. Serum retinol, while less responsive once in a normal range and influenced by infection,[45] provides interpretable data about VAD for public health decision-making and should be used until new assays of vitamin A status are validated, proven reliable and widely available. High-coverage VAS protects children from xerophthalmia, reduces mortality, including measles fatality, and can lower the risk of hearing loss from severe ear infections, but will not resolve the underlying VAD. Only an adequate diet can sustainably raise serum retinol distributions and prevent VAD, which is now achievable via multiple intervention strategies.

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Perspectives in Nutrition Science

Strengthening the Nutrition Data Value Chain for Accountability and Action

Progress, gaps and next steps

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continuous innovation across the value chain; and fostering a culture of data use and sharing.

> Our hope is that the recommendations in this perspectives paper will motivate future financial and political commitments to invest in nutrition data value chain capacities and actions both before and at the 2020 Nutrition for Growth Summit.

Key messages

> The nutrition data revolution is not only about improving the quality, availability and accessibility of data but also requires building capacity and transforming information into sound decisions.

> This end-to-end systems approach is referred to as the Nutrition Data Value Chain because it considers data as a value-adding ingredient that not only serves to describe progress toward nutrition goals but is in fact essential to achieving them.

> Advancing the nutrition data revolution agenda requires: in-country mechanisms for priority-setting and data coordination; operational guidance for strengthening nutrition data systems; capacity development at multiple levels; costed country data plans that are resourced and implemented; dissemination of knowledge and experience;

Introduction

In 2014, the first Global Nutrition Report (GNR)[1] declared that nutrition needs a data revolution, and proposed four actions (**Box 1**). Five years later, we recognize that the revolution is not solely about data but also about building capacity and transforming information into sound decisions.

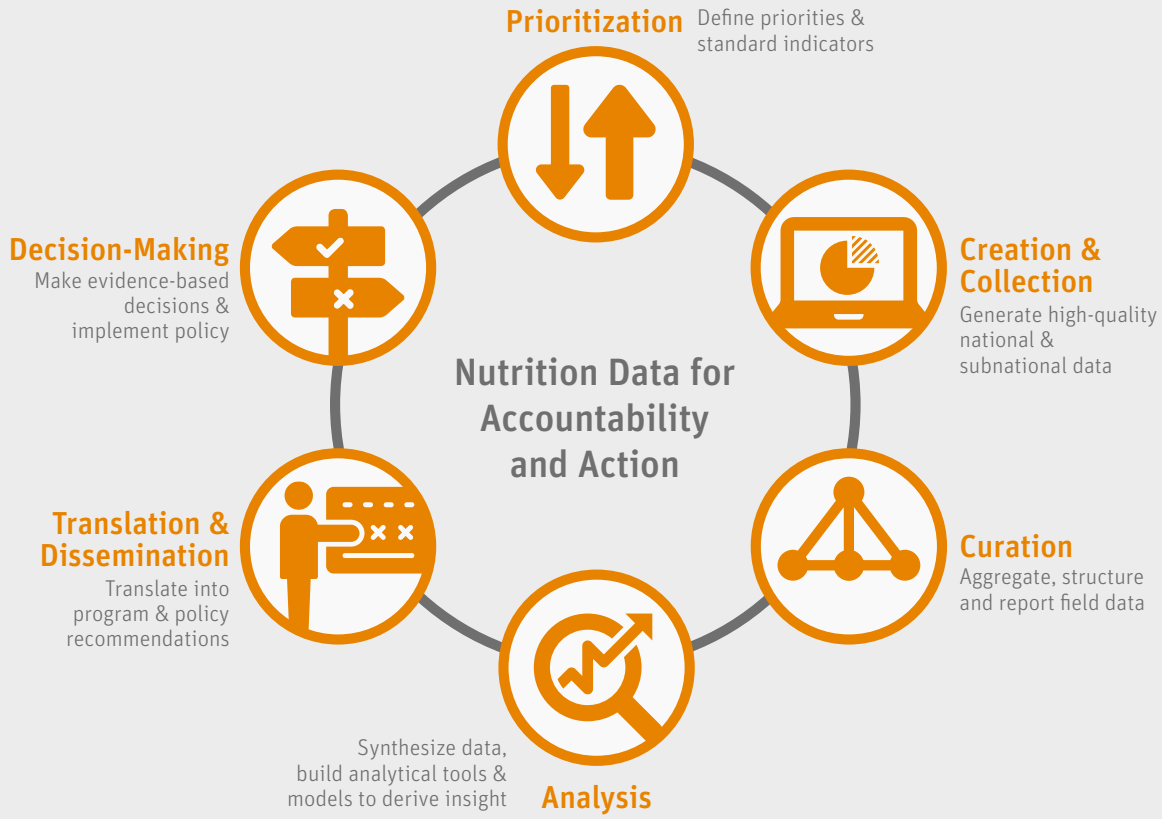
BOX 1: Proposed actions to start a Nutrition Data Revolution

1) Identify data priorities and gaps through a consultative process in anticipation of the SDGs.

2) Invest in nutrition survey capacity so that consistent and reliable national data would be available every 3–4 years.

3) Ensure that high-income countries provide comparable data so that they can be included in progress tracking.

FIGURE 1: The Nutrition Data Value Chain



A global nutrition data ecosystem characterized by strong leadership, consensus on data priorities, and capacity to generate, analyze and use data, analytics, and evidence, is needed to tackle malnutrition in all its forms, and to monitor progress toward SDGs and other global nutrition goals

4) Invest in national and global, interoperable and accessible, nutrition databases to facilitate accountability.

Global Nutrition Report, 2014

In this paper, we take stock of the progress mounting for the Nutrition Data Revolution, and suggest next steps and future investment opportunities to accelerate change. This work is framed in the context of SDG calls for ending all forms of malnutrition (SDG 2.2); leaving no one behind; and building country-data-related capacity (SDG 17). The ideas expand on a short paper we wrote in the 2017 GNR,[2] which introduced the Nutrition Data Value Chain. Country and global examples and suggested actions come from desk studies, SUN Movement Secretariat (SMS) consultations, personal experiences and common sense.

In 2020, the global community will gather in Japan for the second Nutrition for Growth Summit. Our hope is that our recommendations will motivate future financial and political commitments to invest in nutrition data value chain capacities and actions.

> "Data funding should help people transform data into information, information into knowledge and knowledge into action"

The Nutrition Data Value Chain approach

The 2016 State of Development Data Funding report[3] specified that data funding should help people transform data into information, information into knowledge and knowledge into action. This perspective inspired us to propose an end-to-end systems approach to the Nutrition Data Revolution (and its funding) by considering nutrition data from a value chain perspective.

Value chain concepts are increasingly used to describe how the agribusiness sector can contribute to improved nutritional outcomes.[4] Fortification provides a good example of this, whereby micronutrients are added during the milling of staple foods, increasing their nutritional value as they move through the supply chain.

In analogous fashion, the Nutrition Data Value Chain (**Figure 1**) considers data as a value-adding ingredient that not only serves to describe progress toward nutrition goals but is in fact essential to achieving them. The data value chain encompasses multiple links, ranging from prioritization of what to measure and how, through the collection, curation and analysis of this data, and its translation into information and evidence that is widely shared and informs decision-making. This paper describes the links in this chain, with country and global examples of progress and next steps.

Unpacking the Nutrition Data Value Chain

1. Data prioritization

Defining priorities is the first step in the value chain and according to SUN Country Focal Points would require the leadership from coordinating bodies (**Box 2**). SDG 17 calls for immediate capacity-building support to increase the availability of high-quality, timely and reliable data disaggregated by income, age, race, gender, ethnicity, migratory status, disability, geographic location and other characteristics to enable robust progress tracking by 2030. Disaggregated nutrition data are needed to: **1)** characterize nutritional status, dietary practices and deficiencies; **2)** identify root causes; **3)** design policies and interventions; and **4)** monitor implementation and outcome progress for accountability and to inform management decisions.

Unfortunately, there is no global guidance document specifying how frequently this disaggregated data should be collected, but common sense suggests that information for policy formation, intervention design and root cause analysis is needed less often than information for management decisions and accountability tracking, which should be accessible and used annually at a minimum.

BOX 2: Recommendations from SUN Country Focal Points

Data coordination

- Identify a lead actor to coordinate the data and accountability work.
- Engage nongovernment stakeholders including civil society organizations, academia, media, businesses and development partners.
- Map all stakeholders to get a better idea as to who can help where with data and information.

Data prioritization

- Include the World Health Assembly (WHA) Maternal, Infant and Young Child Nutrition (MIYCN) targets and the nutrition-relevant noncommunicable disease (NCD) targets in the planning stage.
- Agree on one multisectoral monitoring and evaluation (M&E) framework that can be used by key stakeholders.

Data collection

- Build capacity at frontline level.
- Use automated systems to improve data quality.
- Coordinate survey implementation.

Data access

- Establish central data repositories that are, at a minimum, accessible to all key stakeholders.

Data use

- Tailor data and information to specific and well-defined purposes.
- Make data publicly accessible and usable.

SUN Consultations, 2016

> "SUN countries have called for clear guidance on nutrition data prioritization"

SUN countries have called for clear guidance on nutrition data prioritization that includes: **1)** a hierarchy of indicator categories; **2)** a dictionary of indicator definitions and operational advice; **3)** suggestions on appropriate data platforms for each category of information; **4)** recommendations on data collection frequency; and **5)** examples of how data should be reported. Tools for capacity strengthening in each of these areas are also needed.

2. Data collection

Once data needs are prioritized, information sources should be identified and an operational data plan for joining up available and new information should be developed and costed. A guiding principle is to avoid creating parallel data systems.

Population-based surveys, such as Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS), are the most common data sources for nutrition but are administered infrequently. Nigeria, Burkina Faso and several West and Central African countries collect nutrition data annually using the Standardized Monitoring and Assessment of Relief and Transitions (SMART) survey methodology.[5] Standardization of

A healthcare worker explains the data of a children's growth chart at a local maternal and child community center where the health workers track interventions and the weight of each child under 3 years of age, in Sogobamba, within the Chinchao district of Huánuco, Peru, on 27 August 2017

indicators across data platforms is the subject of ongoing discussions led by WHO/UNICEF[6] and supported by the Data for Decisions to Expand Nutrition Transformation (DataDENT).[7]

Though national surveys are critically important, none provide the range of indicators needed and few have adequate sample sizes to enable the necessary disaggregation to address the inequity vision of SDGs, which calls for counting multiple subgroups. For example, data on the effective coverage of interventions[8] and financial expenditures are lacking. We recommend georeferencing survey data to enable modeling and mapping[9] that permits visualization of vulnerable populations, in line with the goal of leaving no one behind.

"High-quality, timely data is essential for decision-making"

High-quality, timely data is essential for decision-making. Peru is an example of a country that reduced stunting by half in 10 years. This outcome was strongly enabled by regular surveys, robust monitoring and the use of timely data for results-based budgeting.[10]

UNICEF is currently documenting the range of nutrition indicators used in country health information systems and will be developing global operational guidance. Standardizing and automating this information should improve local decision-making with standardized methods and clearly defined denominators.

Innovations are needed in several areas to reduce the cost and complexity of nutrition data collection from all sources: administrative, survey and, where appropriate, crowdsourced. Recent innovation has focused on technology-enabled automated processes, including auto-calculated fields and logical validation rules within data collection forms and the use of mobile technology and open-source software such as RapidPro[11] to collect data in real time. Advances are needed across a range of issues from improved sampling methodologies to validated methods for assessing the coverage and quality of interventions, as well as easier and more accurate means for measuring food intake,[12] length and body composition[13] and micronutrient status.[14] Additionally, innovations are needed to strengthen methods used in nutrition early warning systems, particularly for areas that face repeated crises.[15]

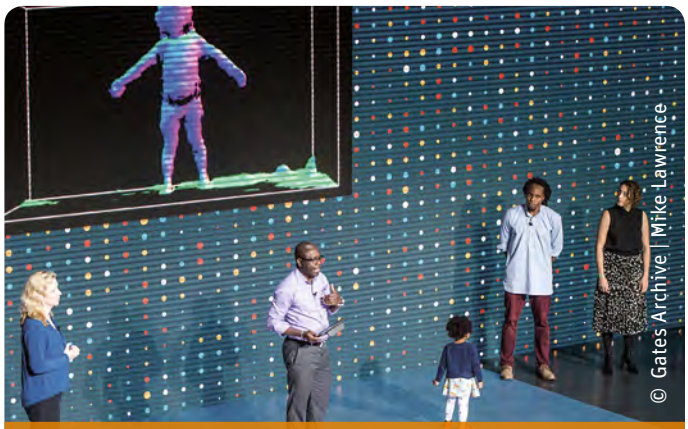
3. Data curation

Nutrition data comes from various sectors that have limited ability to connect in a coordinated manner (also referred to as systems interoperability), making curation of joined-up analyses challenging. The Global Partnership for Sustainable Development Data,[16] Global Open Data for Agriculture and Nutrition (GODAN),[17] and the Health Data Collaborative[18] are examples of global initiatives that promote data interoperability and open access. The Ethiopian Public Health Institute is creating a National Data Management Center[19] that allows analysis across multiple datasets and includes a national data-sharing policy, with nutrition support from the National Information Platforms for Nutrition (NIPN) initiative.[20] Concepts of interoperability and open access have not fully permeated the nutrition data ecosystem and are areas for future attention.

4. Data analysis

Strengthening analytic capacity was a priority expressed in many country discussions, particularly for the use of tools to derive

Antonio Sousa Macaho, supervisor at the Demographic Surveillance System (DSS) program from the CISM (*Centro de Investigação em Saúde de Manhiça*), uses a new electronic device to gather demographic information in Malavela village, Manhica, Mozambique, on 17 December 2011



Maria Elena Jefferds and Karim Bougma demonstrate the body scanning app on stage during The Goalkeepers 2018 event, at Jazz at Lincoln Center in New York, NY, USA, on 26 September 2018

insights and display information for decision-making. Initiatives such as Countdown to 2030[21] and Transform Nutrition West Africa[22] are supporting regional networks to build this capacity, using data from multiple sources. Today, nearly 70 countries use the open-source, web-based District Health Information Systems 2 (DHIS2) health management information system,[23] with features that enable rapid analysis, visualization and dashboard production. In addition, several nutrition modeling tools are available to analyze and synthesize data to aid program planning[24] and optimization,[25,26] impact forecasting,[27] visualization[28] and advocacy.[29] A Nutrition Modeling Consortium was recently constituted to facilitate dialogue among tool developers and to compare assumptions and improve tool interoperability and uptake.[30]

5. Data translation and dissemination for use in decision-making

Translating analysis into action is at the heart of the data value chain approach. All too often, information is not synthesized and packaged to facilitate this. At the global level, there is a need for continuous, inclusive and evidence-informed dialogue to advance the nutrition agenda forward. Several initiatives, including the GNR,[31] the Global Panel on Agriculture and Food Systems for Nutrition,[32] and various Lancet Nutrition Series[33,34] and Commissions,[35,36] have integrated evidence and data, and used these outputs for policy-oriented communication. There is an expanding number of nutrition reports and accountability tools in use today, with some conflicting messages.[37] However, as emphasized by all SUN Focal Points, improved management decisions and accountability require data to be accessible and usable at national and local levels.

A call for immediate action

The transformations that are needed to achieve the SDGs require new ways of thinking. When it comes to data, the discussion cannot solely be about aggregating information upward; it must be about fully exploiting information to make informed program and policy decisions that contribute to improvements in nutrition and other SDG outcomes. This will not be achieved without significant investments in data value chain capacities.

> "Translating analysis into action is at the heart of the data value chain approach"

Garnering commitment and resources for nutrition data requires that we have clear priorities, understand the data gaps and have identified the platforms and institutions that will provide and use the information. This requires leadership, coordinated efforts, costed data plans and financing. Some may argue that investing in data is resource-inefficient compared with delivering interventions and services. There are, however, examples of how nutrition data investments can pay for themselves through more efficient and effective programs. For example, an economic optimization study from Cameroon used national survey data to suggest policy changes in the national vitamin A program that could achieve the same effective coverage at 44 percent of the cost.[38]

Advancing the nutrition data revolution agenda requires: **1)** in-country mechanisms for priority-setting and data coordination; **2)** operational guidance for strengthening nutrition data systems; **3)** capacity development at multiple levels; **4)** costed country data plans that are resourced and implemented; **5)** dissemination of knowledge and experience; **6)** innovation across the value chain; and **7)** fostering a culture of data use and sharing.

Some of these actions are more straightforward than others, and all seven present unique challenges. However, without this investment, the SDG target of ending malnutrition in all its forms will be much harder to achieve.

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The Nutrition Modeling Consortium: Improving Data Use for Nutrition Policy

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Key messages

- Mathematical modeling tools help policymakers maximize the efficiency of their nutrition investments.
- Three examples are provided that highlight how different tools were used to weigh policy trade-offs, identify savings and improve access to nutritious diets.
- More work is needed to improve end users' understanding of the tools' potential, and to smooth out between-tool interoperability.

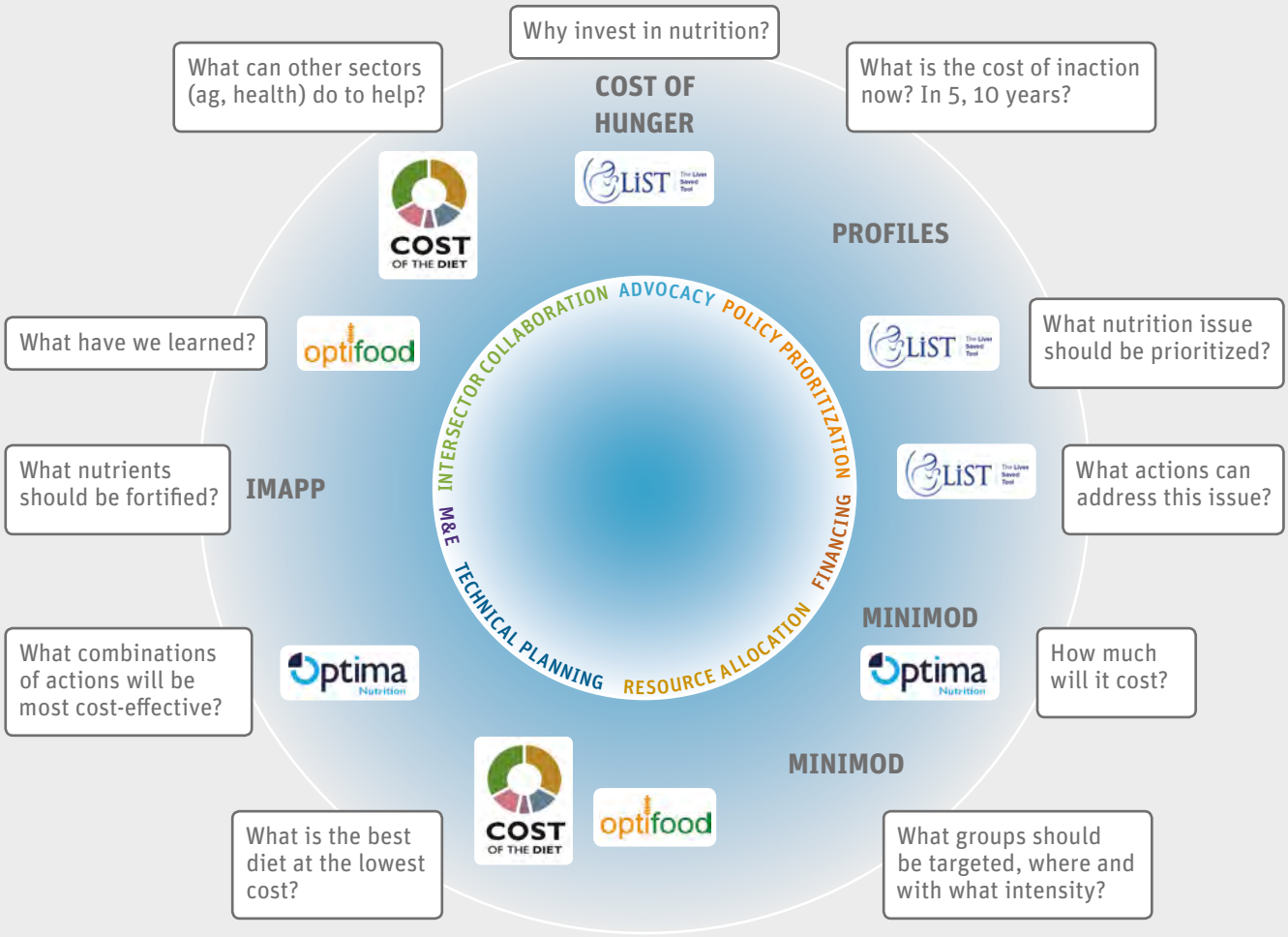
Introduction

Growing recognition of the centrality of nutrition to human and social development is prompting policymakers in low- and middle-income countries (LMIC) to invest in nutrition, yet their capacity to prioritize among interventions and to allocate resources efficiently remains a challenge. Indeed, the range of questions facing policymakers is overwhelming: What are the most urgent nutrition goals to address – child stunting, vitamin A deficiency or anemia? Which interventions will achieve those goals most cost-efficiently? And how can the benefits from this investment on social development over the next 10 years be compared with other interventions in the education, health or other sectors? Such questions, though difficult, need to be considered for informed policy decisions.

"The range of questions facing policymakers is overwhelming"

The core group of the Nutrition Modeling Consortium, photographed in February 2018. From left to right, **front row** (sitting): Rebecca Heidkamp, Lynnette Neufeld, Gilles Bergeron, Neff Walker, Florencia Vasta. **Middle row** (also sitting): Kavita Sethuraman, Saskia de Pee, Nick Scott, Monica Woldt, Homero Martinez, Elaine Ferguson, Patrizia Fracassi. **Back row** (standing): Saima Ahmed, Megan Bourassa, Saskia Osendarp, Steve Vosti, Frances Knight, Kara Greenblatt, Lindsay Allen, Banda Ndiaye, Nick Kassebaum, Jakub Katiekek, Carol Levin.

FIGURE 1: Cycle of policy decisions and corresponding tools



A tool like PROFILES will demonstrate the cost of inaction to the national economy and indicate what nutrition conditions (e.g., stunting, anemia or vitamin A deficiency) need most urgent attention. Having clarified national priority investments, PROFILES results can then be used by LiST to examine how many lives and DALYs (disease-adjusted life years) will be spared by alternative interventions on a given priority, comparing for instance the impact of exclusive breastfeeding (EBF) versus micronutrient powder supplementation (MNP) on the reduction of stunting.

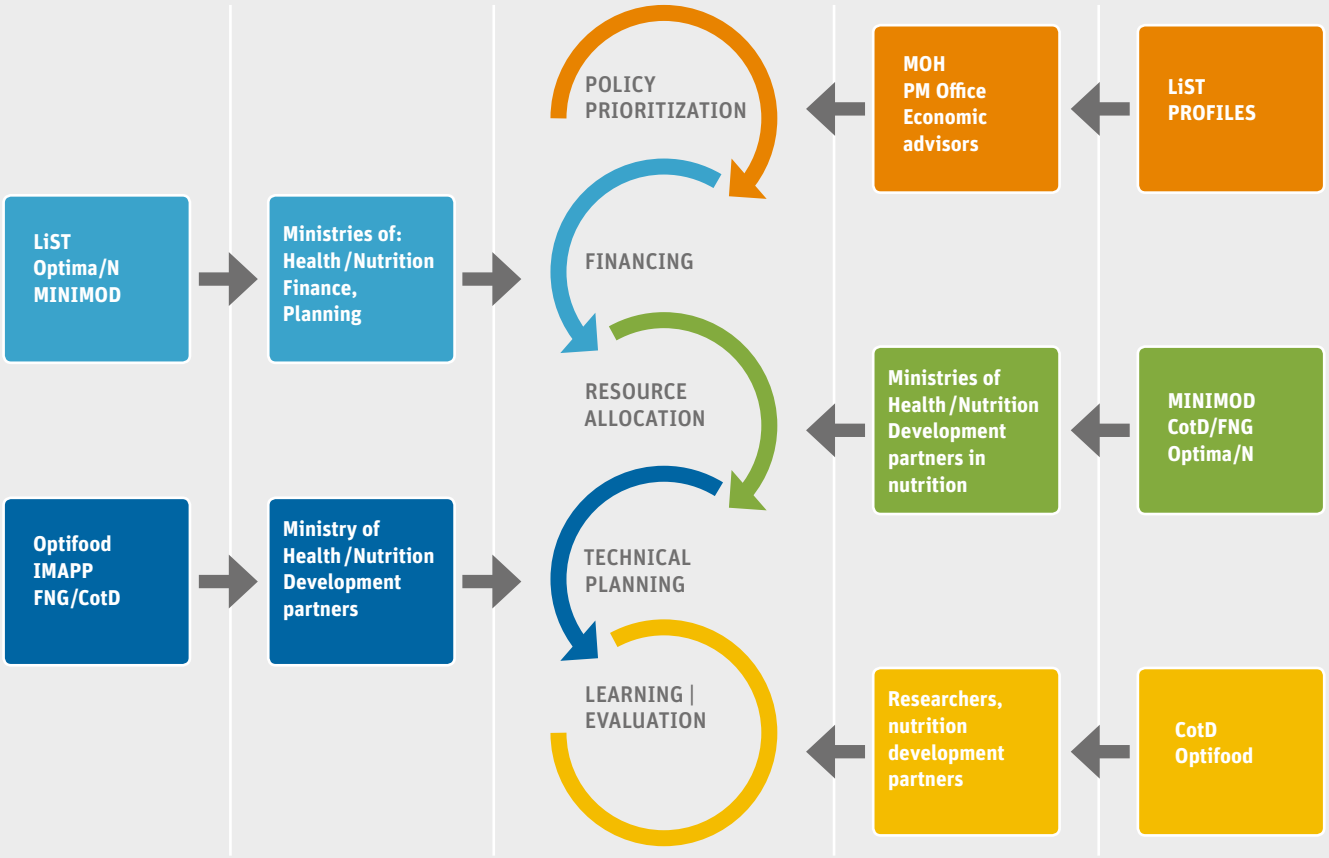
LiST does only one intervention at a time, however: what about the effects of multiple interventions on different outcomes? A tool like Optima Nutrition (Optima/N) will state what 'quantity' of each intervention is needed to obtain the optimal outcome on various conditions (e.g., stunting and child mortality). It will also permit statements about how much more could be achieved with greater budgets, and how those additional resources should be allocated across interventions. To refine this further, a tool like MINIMOD will allocate resources over space and time and among target groups, taking into account the regional severity of the problem, thus allowing policymakers to modulate interventions according to their most cost-effective combination in each region. Other sectors, such as agriculture and education, exert a powerful influence on the context in which malnutrition occurs. Tools like Cost of the Diet (CotD) and Optifood can guide multisectoral actions that are sensitive to nutrition programming needs.

Considerable work has already been done by computer modelers and nutritionists to guide such policy decisions. Tools have been developed to support nutrition actions, from advocacy to financing to resource allocation to learning (Figure 1). Those efforts, however, have been constrained by two key challenges. First, each tool was developed independently by different organizations to pursue different goals using different methods and data. This can generate inconsistent, even conflicting, recommendations. Second, end users are still largely unaware of those tools and their powerful capabilities. Consequently, uptake remains slow and is largely driven by tool modelers themselves rather than by endogenous programmatic demand or policy needs.

The Nutrition Modeling Consortium

To resolve the lack of connection between tools, and to increase uptake by end users, the New York Academy of Sciences, the Micronutrient Forum and the Bill & Melinda Gates Foundation convened a series of meetings between 2017 and 2019 that

FIGURE 2: Tag teaming between teams along the policy process



Adapted from personal communication from Purnima Menon, 2018

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The dietary needs of adolescent girls and young children differ significantly

resulted in the creation of the Nutrition Modeling Consortium (NMC). Membership in the NMC is open to all modeling efforts that use mathematical optimization to improve the allocation of nutrition resources. The NMC currently includes 14 tools (see Table 1), each addressing one or more steps along the 'policy cycle' illustrated in Figure 1.

A leading mandate of the NMC is to disseminate information to end users in LMIC about the purpose and capabilities of those tools and how they can be applied to address countries' specific needs, and also about how to obtain services through the Consortium. A second mandate is to discover and advance the tools' collective capacities, harmonize them and further their complementarity and interoperability. This includes, for instance, helping to normalize the evidence and assumptions they use to ensure that their results are not contradictory and that they coherently 'tag team' with one another when possible to support the entire nutrition portfolio development (Figure 2).

Achieving harmonization is a complex proposition, however. Aside from its aim and origin, each tool differs in its assumptions, objective functions and mathematical approaches. To bring them together, the NMC plans to pilot the simultaneous rollout of several tools in one location so that modelers can de-

TABLE 1: Tools currently in the Consortium and its parent organization

Tool name (acronym)	Parent organization	Brief description
Cost of the Diet | Fill the Nutrition Gap (COD)	Save the Children | World Food Programme	Models the lowest-cost, nutritionally adequate diet for model households and for individual groups, depending on the nutrient requirements of each member.
Cost of Hunger (COH)	Economic Commission for Latin America	Analyzes the cost of the double burden of under- and overnutrition on social and economic issues, and how much could be saved by addressing those nutritional problems.
EQUIST (EQU)	UNICEF	Identifies cost-effective interventions, prioritizes key bottlenecks, and targets the most effective and equity-focused strategies to remove bottlenecks to MNCH (maternal, newborn and child health) intervention coverage.
GHCC (GHC)	Washington University	Improves the availability of cost estimates and offers guidance to standardize costing in global health. Focus is on health (especially HIV and TB), not on nutrition.
IMAPP (IMP)	University of California, Davis	Supports the 2006 WHO / FAO Guidelines on Food Fortification using current consumption of potential fortification 'vehicles': what amount of nutrient to add for a targeted prevalence of inadequacy?
IHME (IHM)	Washington University	Provides rigorous and comparable measurement of the world's most important health problems, and evaluates the strategies used to address them.
LiST (LiS)	Johns Hopkins University	Models how changes in coverage of efficacious interventions affect mortality, stunting, wasting, breastfeeding practices, birth outcomes and maternal anemia.
MAPS (MAP)	London School of Hygiene & Tropical Medicine	Assesses how actions in food and agriculture systems can address micronutrient deficiencies, using economic optimization and subnational-level spatial environmental data to forecast food consumption.
MINIMOD (MNM)	University of California, Davis	Identifies cost-effective solutions to specific micronutrient-related problems. Includes an economic optimization tool to compute the cost of an intervention per child reached or effectively covered.
Nutrition & Child Development	Harvard University	Models nutrition interventions to human capital outcomes, child development, educational attainment, adult cognitive / socioemotional development and lifetime earnings.
OMNI (OMN)	Nutrition International	Integrates program coverage and intervention efficacy data to assess health and other impacts that result from nutrition programming, across multiple interventions.
Optifood (OPF)	London School of Hygiene & Tropical Medicine	Assesses the nutritional adequacy of local food environments and the affordability of a nutritious diet. Identifies problem nutrients and strategies to address gaps using food-based recommendations.
Optima Nutrition (OPM)	Barnett Institute | World Bank	Assesses how to allocate a specified amount of funding such that it maximizes nutrition outcomes in the most cost-effective way possible.
PROFILES (PRF)	FANTA | USAID	Raises awareness among policymakers of the impact of malnutrition on child mortality, morbidity and labor productivity by showing the consequences of status quo over a defined time period.

termine how their results can inform the use of other tools. The intuition behind such harmonization is illustrated in **Figure 2**: tools like LiST and PROFILES help top-level decision-makers prioritize the issues to be addressed. Once agreed, these are passed to tools like Optima/N to examine action(s) to be taken. Next, MINIMOD and CotD can allocate resources geographically and among target groups.

Preliminary results from such collaborations are expected later in 2019. In the meantime, and to illustrate the potential utility of those tools to country governments, we provide three examples below that illustrate how the use of individual tools in the past helped decision-makers reach better solutions.

1. Cost of the Diet (CotD) identifies ways to make a nutritious diet more affordable in Pakistan

The 2011 National Nutrition Survey in Pakistan found that 43.7% of children < 5 years were stunted, 31.5% underweight and 15.1% wasted. A CotD analysis was applied as part of the Fill the Nutrient Gap (FNG) process in 2016–17 to better understand the provincial malnutrition contexts, and to align actions at national and provincial levels. It sought to address the following questions:

1. What are the barriers to adequate nutrient intake?
2. What is the cost and content of the least expensive diet for specific members of modeled households (breastfed child, lactating woman, etc.), using locally available foods and appropriate portion sizes?
3. What proportion of the population could afford a nutritious diet?
4. What interventions could improve access to nutritious diets?

The Cost of the Diet (CotD) software analyzes the amounts, combination and cost of local foods needed by households to have nutritious diets. CotD uses linear programming to find optimal combinations of available foods that meet energy, macronutrient and micronutrient needs for households and specifically targeted household members, e.g., adolescent girls. The tool allows users to model the impact of potential interventions on improving the quality and affordability of diets. Results can also be used for advocacy, to influence nutrition policies and programs and (if run regularly) as an early warning indicator.

CotD analysis of local foods in rural and urban areas showed: that food availability was not a barrier to a nutritious diet but that nutritionally adequate diets would be unaffordable for 68% of households; that the nutrient requirements of adolescent girls were the most expensive to meet; and that calcium, iron and vitamin B_{12} were the key problem nutrients based on local food availability and prices.

Among interventions identified for increasing the affordability of a nutritionally adequate diet, vouchers for animal-source foods and vegetables were most effective in meeting adolescent girls' nutrient needs, while fortified cereal and legume blends were best to meet the nutrient needs for children 6–23 months and pregnant and lactating women. However, no single intervention alone would significantly reduce the cost of a nutritious diet across households. Those two interventions were thus combined with cash transfers, producing the greatest impact on the affordability of nutritious household diets.

Details of these packages and accompanying stakeholder-developed recommendations can be found in the Pakistan Summary Report (at **www.wfp.org/fillthenutrientgap**).

The MINIMOD tool is designed to improve the efficiency of micronutrient intervention programs. Starting from a 'business-as-usual' (BAU) scenario (retaining current micronutrient intervention programs), it asks what the impacts and costs would be of alternative programs over a 10-year planning time horizon, and what would be the most cost-effective program or combination of programs for achieving agreed-upon objectives.

2. MINIMOD identifies more cost-effective strategies for addressing vitamin A deficiencies among young children in Cameroon

Vitamin A (VA) deficiency is common in Cameroon, but shows large regional variations in terms of prevalence and severity (**Figure 3**). The cost of existing programs also varies – for example, the yearly cost of high-dose vitamin A supplementation (VAS) per child reached ranges from US$0.66 in the north to US$2.05 in the south (**Figure 4**), due to regional differences in population densities, infrastructure and so forth, all of which affect region-specific program coverage.

MINIMOD uses economic optimization routines to estimate the efficiency gains (vis-à-vis a Cameroon business-as-usual (BAU) scenario involving national VAS distribution and an underperforming VA-fortified edible oils program) that could result from regional VAS targeting and other investments, such as improving the VA-fortified edible oils program and developing a VA-fortified bouillon cube program.

Figure 5 identifies the most cost-effective interventions to achieve adequate VA intake in the south macro-region of Cameroon, where baseline levels of inadequate VA intake are relatively

FIGURE 3: Vitamin A deficiency among children < 5 years by region in Cameroon

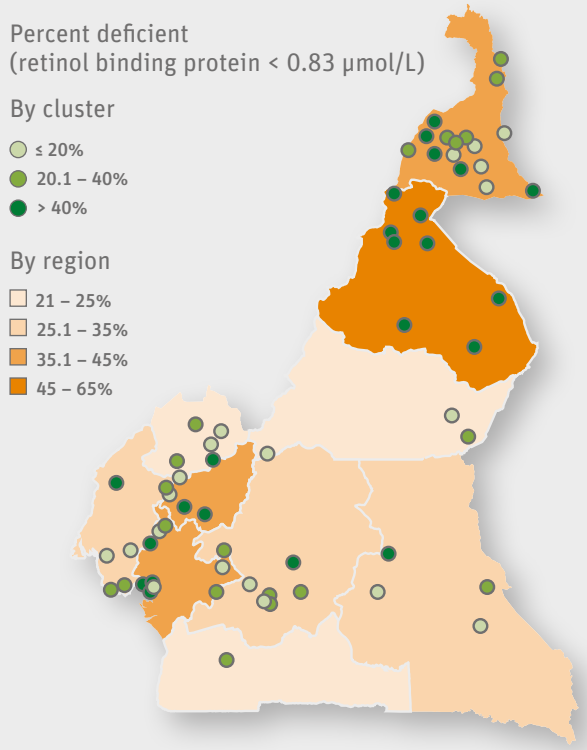
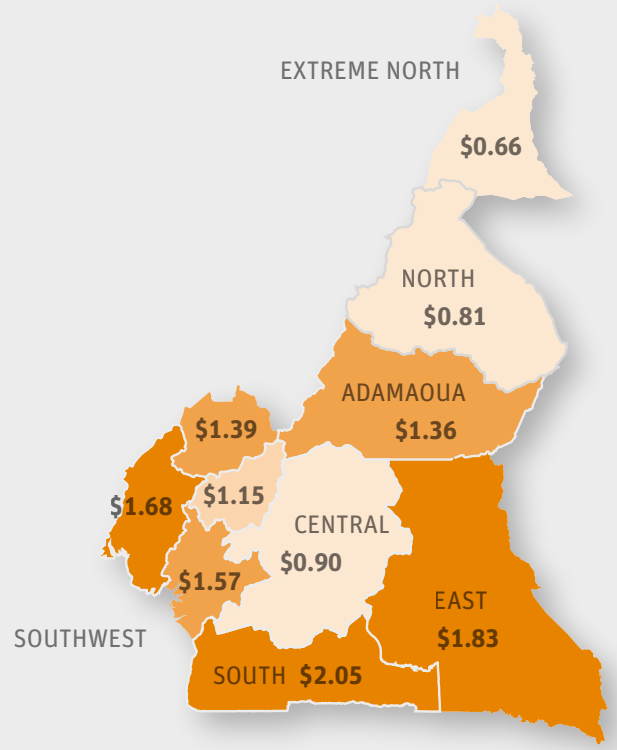
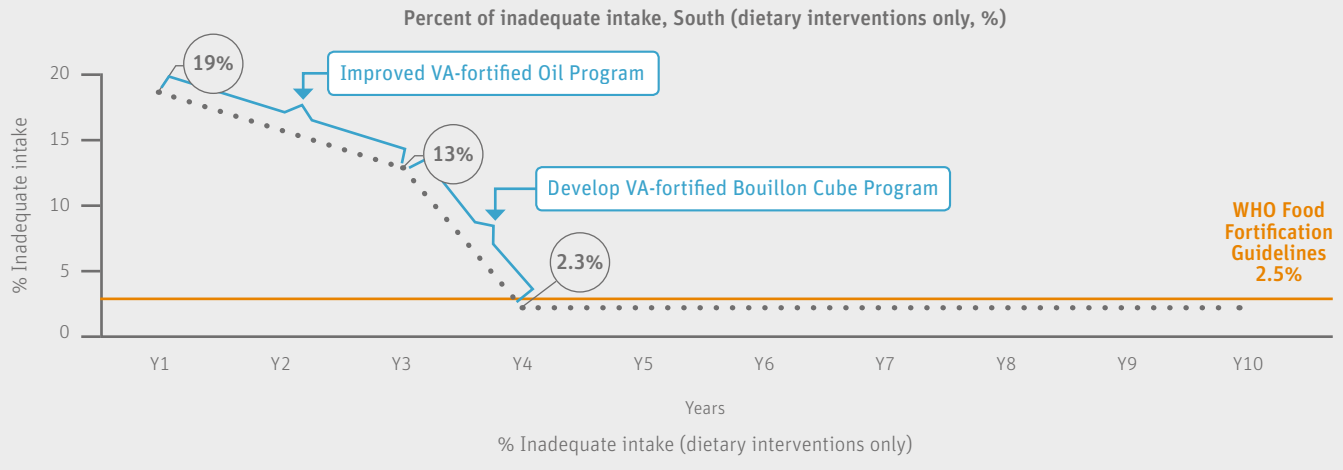


FIGURE 4: Yearly cost per child reached with vitamin A capsules in Cameroon



low (19%) and VAS costs are high (US$2.05 per child reached). For this macro-region, the tool suggests that improving the edible oils program and developing a fortified bouillon cube program could, jointly, within 4 years essentially eliminate inadequate VA intake (< 2.5%). Savings from doing so could be as high as US$5.4 million. Similar results emerge for the cities macro-region (not shown). However, in the north macro-region (not shown), where the prevalence of inadequate VA intake among children is very high (~60%), the fortification programs alone cannot eliminate this public health problem. Therefore, until new food-based delivery platforms can be implemented, VAS will need to continue in the north macro-region. The policy choices that emerged from these analyses are clear and important, and highlight the inefficiencies in this case of maintaining BAU.

FIGURE 5: Combination of cost-effective strategies for addressing vitamin A deficiencies in children – Cameroon, south macro-region



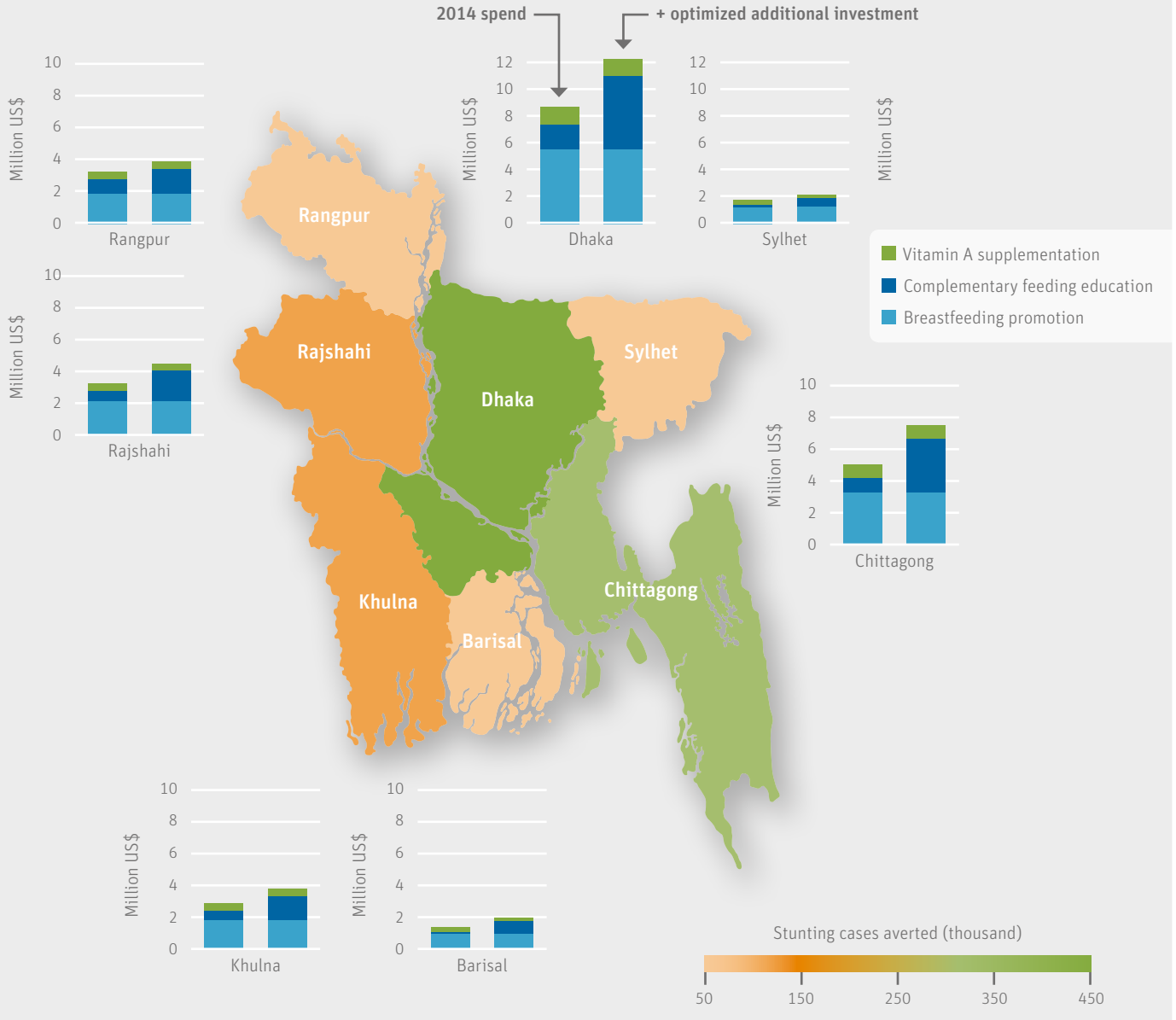
Optima Nutrition (Optima/N) aims to provide practical advice to governments on the allocation of current or projected budgets across programs to minimize stunting, wasting, anemia or under-five mortality at both the national and regional levels. Planners may choose from interventions that include vitamin supplementation programs, IYCF (infant and young child feeding) education, treatment of SAM (severe acute malnutrition), treatment and prevention of diarrhea, fortification of foods, WASH (water, sanitation and hygiene), family planning and malaria prevention interventions.

3. Optima Nutrition (Optima/N) helps to identify the best mix of interventions to reduce stunting in Bangladesh

Costing nutrition interventions, assessing their cost-effectiveness and doing cost–benefit analysis are well-refined analytical routines. Until Optima/N, however, one question eluded an answer: what is the optimal allocation of resources across interventions to obtain a given outcome (e.g., maximizing the number of non-stunted children < 5 years)? Optima/N answers such questions as:

- How can a fixed budget be allocated across interventions to minimize stunting, wasting, anemia and mortality in children < 5 years?

FIGURE 6: How can an additional US$10 million be optimally allocated across regions and programs in Bangladesh to minimize stunting?



- Which programs and regions should receive further funding, if funding were available?
- How might trends in undernutrition change under different funding scenarios?
- How close can the country get to its target under a BAU scenario versus the same funding level but reallocated optimally?
- What is the minimum funding required to meet the nutrition targets if allocated optimally?

An Optima/N application was conducted in Bangladesh to determine how an additional US$10 million could be allocated across regions – and to a selection of interventions within those regions – to minimize stunting (**Figure 6**).

The analysis suggested that the greatest number of stunting cases could be averted by focusing on Dhaka and Chittagong. Both regions would absorb the lion's share of funding, with complementary feeding education and VAS being the priority interventions for the additional funding. Other regions were also allocated a slight increase in funding but it contributed less to the total reduction in stunting, even after their package of interventions had been optimized. Such findings create context for the political choices that may drive policy decisions.

"Collectively, these tools provide extraordinary opportunities to effectively use data in nutrition planning"

Conclusions

The three analyses above offer a glimpse of the possibilities offered by modeling tools. Other aims not described here include advocacy (using PROFILES and Cost of Hunger), intersectoral planning (Optifood), food fortification program design (IMAPP) among others. Collectively, these tools provide extraordinary opportunities to effectively use data in nutrition planning. The fact that each tool was developed independently from the others and with distinct goals in mind inherently creates the possibility of seeing diverging recommendations but the creation of the Nutrition Modeling Consortium and the activation of its mandate will hopefully make it possible to preview and mitigate such challenges. More information on the Consortium and on each of the tools is available at **www.nyas.org/NMC**

Acknowledgements

The author would like to thank (in alphabetical order) Reina Engle-Stone, Saskia de Pee, Frances Knight, Nick Scott and Steve Vosti for their review.

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Bridging India's Evidence Gap in Nutrition Through Administrative Data

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Evidence for Policy Design (EPoD) India at the Institute for Financial Management and Research (IFMR), New Delhi, India

Key messages

- Nutrition data is often infrequently collected, unreliable and noncomparable across time and regions, making it difficult to track progress in real time.
- Administrative data represents a goldmine of actionable information, with the potential benefits of timeliness and full coverage of program participants. But governments need to focus their efforts in improving the quality of administrative data.
- Administrative data collection is projected as a goal with strict timelines, thereby putting pressure on frontline workers to meet deadlines without paying attention to the quality of the data collected.
- We propose a systematic strengthening of data collection procedures that can produce accurate and actionable information.
- This includes:
  - intensive training of actors across tiers, as well as review of the existing equipment against the ideal requirement;
  - incentivizing frontline workers and mid-level officials to accurately report malnutrition status; and
  - systematic triangulation of collected data through independent checks.

Malnutrition: a crucial development challenge

Malnutrition is one of the most crucial development challenges facing India today. The Government of India has invested significant resources to address it, and has achieved some positive results to date. However, targeting different aspects of this problem will require detailed real-time information to monitor progress and plan resource allocation.

The good news is that there is an enormous and largely underused resource of administrative data that can assist India in tracking and addressing malnutrition. Administrative data collected by frontline workers could serve as a rich data source for guiding India's nutrition policies. As it stands, these data are often considered too unreliable to serve as a basis for policy decisions, but there are concrete steps the government can take now to improve this data source.

> "Administrative data collected by frontline workers could serve as a rich data source guiding India's nutrition policies"

As researchers at Evidence for Policy Design (EPoD) India at the Institute for Financial Management and Research (IFMR), we have been working towards building capacity of policy stakeholders in improving the effectiveness of service delivery, targeted at improving nutrition status. This often involves discussions with officials at different administrative levels – state, district and block officials as well as frontline workers – to understand the challenges facing the current data systems. In this article, we review major data systems on nutrition in India and highlight the human and organizational contributors to their quality. We also discuss some low-cost opportunities to improve the current systems for dealing with malnutrition.

Data in nutrition – miles to go

According to the latest Global Nutrition Report, we have come

a long way globally in addressing malnutrition in terms of better policy, financing, data collection and analysis. In India too, as per the fourth round of the National Family Health Survey (NFHS-4), the proportion of stunted children has decreased, from about 42 percent in 2005 to 35 percent in 2014–15. Even with these estimates, the development burden of malnutrition is still extremely high. In 2009, leading development economists Angus Deaton and Jean Drèze suggested that despite India's rapid economic growth, levels of undernutrition were higher than in many Sub-Saharan African countries.[1] Even after a decade, this continues to be true – India is home to about 50 percent of the undernourished children in the world, according to a joint study by The Associated Chambers of Commerce and Industry, and Ernst and Young, in 2015.[2]

How can India solve this deep-seated problem of malnutrition? One way to begin is to track malnutrition using consistent real-time data to diagnose immediate problem areas.

Nutrition data is extensively available from a variety of sources. However, such data is often infrequently collected and non-comparable across time and regions, making it difficult to track progress in real time.[3] Despite these limitations, we advocate exploring ways to strengthen existing data systems to better inform policy and program interventions targeting nutrition outcomes.

Where do we stand in terms of existing data systems?

NFHS data has long been a key reference point for policymakers, researchers and civil society in the health, family planning and nutrition domains. Much of this trust comes from the fact that NFHS data is collected and coordinated by a leading Indian research institute, namely the International Institute for Population Sciences, and is one of the most representative large-scale datasets that is independent of government data. But the long interval between subsequent rounds of NFHS surveys – there was a gap of 10 years between rounds three and four – creates a data void that inhibits analysis of a dynamic problem such as malnutrition. Additionally, reports in the media have highlighted poorly trained field agents and lengthy questionnaires as concerns regarding NFHS data.[4]

What other sources of data can nutrition policymakers rely on? The progress of national- and state-level nutrition missions and multiphase programs can be monitored and evaluated only through administrative datasets. Administrative data represents a goldmine of actionable information, with the potential benefits of timeliness and full coverage of program participants. We divide these administrative data systems into three types.

1. Centrally designed ICDS-Rapid Reporting System

Integrated Child Development Services (ICDS) is a centrally designed program for providing nutrition services. Under the existing data system of ICDS, *Anganwadi* workers, who are community-based frontline workers, are required to maintain 11 different registers for collecting information on supplementary nutrition services, child growth monitoring, pregnant and lactating mothers, preschool education, immunization and the village census.[5] This information is collated monthly at the level of *Anganwadi* centers, which are the centers for nutrition-based services for mothers and children in India, and transferred into a centrally operated system called the Rapid Reporting System.

2. Centrally designed ICDS-CAS

The Women and Child Development (WCD) ministry in India implemented the ICDS System Strengthening and Nutrition Improvement Project (ISSNIP) in 2016 with the objective of strengthening the ICDS service delivery. This initiative introduced a software application called ICDS Common Application Software (ICDS-CAS) for *Anganwadi* workers to capture data in real time on electronic devices, such as mobile phones and tablets. It is also meant to replace 10 of the existing 11 data registers. This innovation is currently in its pilot phase in 162 districts across eight states. *Anganwadi* workers continue maintaining their registers during this pilot stage, doubling their data entry burden. While the pilot states brainstorm ways of using this data, it might be too soon to assess its role in targeting nutrition interventions.

3. State-specific data systems

Some states in India also have parallel data collection systems. For instance, e-Pragati[6] is Odisha's (an eastern state in India) version of the ICDS-Rapid Reporting System to collect sectoral information (a sector is a group of 25–30 *Anganwadis*). Similarly, Chhattisgarh (a central state in India) collects anthropometric information to assess nutrition outcomes for all children aged less than six through an annual event called *Vajan Tyohar* (Weighing Festival).[7] Most state officials also depend on tabulated formats typically prepared using Microsoft Excel. However, these formats focus more on service-delivery information than on childhood nutrition outcomes.

Nutrition-related administrative data is underutilized despite the enormous efforts spent on its collection. Its use by researchers and civil society actors is restricted, as the data is not available publicly. Government officials are either not motivated or else do not trust the reliability of this data. This lack of trust is not misplaced. One of our back-of-the-envelope calculations based on weight-for-age Z-scores (WAZ) showed that the difference between malnutrition estimates from the NFHS and the ICDS-Rapid Reporting System in a district was about 25–30 percentage points.

Why is our administrative data not reliable?

If administrative data is collected consistently, why isn't it con-

sidered a reliable source of data for monitoring nutrition outcomes? While there are many reasons, we have identified the following four as key.

1. Skill gap concerning anthropometric measurements

Practitioners commonly use anthropometric indicators to identify childhood malnutrition by comparing the weight and/or height of children to age-specific standards defined by the World Health Organization (WHO). *Anganwadi* workers receive training on weight measurement, but this takes place only when they are first hired, and with infrequent follow-ups. Training courses on height measurements are even less frequent, as the provision of ICDS services is based on weight instead of height. Our observations from the field reveal that *Anganwadi* workers falter on basic measurement processes, implying the need for retraining. The ministry and state departments seem to underestimate the rigor required in height and weight measurements, and neglect the importance of regular high-quality training of frontline workers on these aspects.

2. Availability of appropriate measurement equipment

Lack of appropriate measurement equipment exacerbates the effects of the skill gap among frontline workers. There is a visible inconsistency in the quality and type of equipment available at *Anganwadi* centers. For instance, some *Anganwadi* workers measure weight using a Salter (analogue) scale, while others depend on a digital scale. The error rates vary between these machines, the former being more prone to mismeasurement. *Anganwadi* workers also don't have age-appropriate instruments for height measurement.

3. Recording of data

The process of recording data is another entry point for bias. *Anganwadi* workers enter data in registers and lady supervisors collate it into Monthly Progress Reports, another paper-based format. Before finally entering it into the data system, block officials or lady supervisors make corrections, which are largely intuitive in nature. This is where most of the data discrepancy and mismatch is likely to happen. The digital application ICDS-CAS can potentially overcome this challenge by directly locking the data into the system at the first entry point. However, digitization of data may prove to be a double-edged sword, posing many challenges such as internet issues, device breakdown and frontline resistance to change.

"The heart of the data quality challenge is the classic problem of misalignment of incentives"

4. Misaligned incentives

The heart of the data quality challenge is the classic problem of misalignment of incentives since those who are collecting data are also responsible for delivering services and affecting outcomes. This conflict of interest disincentivizes accurate data reporting, and primarily arises from the enormous pressure on states to present a favorable picture of nutrition in their jurisdiction. This pressure gets transferred to middle-level officials and finally trickles down to *Anganwadi* workers. In their dual role as data collectors and last-mile service providers, *Anganwadi* workers hold the power to 'generate' evidence that speaks well of their performance.

Administrative focus then shrinks to simply ensuring timely and complete data collection, thereby inducing pressure on *Anganwadi* workers to meet deadlines without paying attention to the quality of the data collected. At times, they face negative repercussions or punitive actions upon noncompletion, which magnifies their fear of being reprimanded. The easiest way for *Anganwadi* workers to circumvent these pressures is to carry forward the data from the previous time period without actually collecting updated and new information.

"We must incentivize frontline workers and mid-level officials to accurately report malnutrition status"

What are some low-cost solutions to improving administrative data quality?

We propose a systematic strengthening of data collection procedures that can produce accurate and actionable information to justify the amount of time, effort and resources dedicated currently. This revamp involves a centralized change in the protocol for anthropometric measurements, including intensive training of actors across tiers as well as review of the existing equipment against the ideal requirement. But this may not be sufficient unless we incentivize frontline workers and mid-level officials to accurately report the malnutrition status. Furthermore, we suggest systematic triangulation of collected data through independent checks. If designed meticulously, these checks can be sufficient for testing even smaller samples of data, keeping the costs of such an exercise fairly low.

Another relatively low-effort, high-value approach is to broaden the definition of nutrition data by focusing on multisectoral convergence – that is, utilizing data from different sectors.[8] Since nutrition outcomes are impacted by factors such as health and sanitation, decision-makers ought to look across the spec-

trum of administrative data to better understand the nutrition landscape. This could involve monitoring key indicators from other sectors such as information on antenatal care, institutional deliveries and breastfeeding from the Health Management Information System, as well as information on open defecation and access to toilets from the Swachh Bharat Mission Management Information System.[9]

> "By leveraging its frontline personnel, the Government of India can create a strong administrative data system to support policies designed to tackle malnutrition"

Conclusion

By leveraging its extensive network of almost 2.8 million frontline personnel in around 7,000 administrative blocks, the Government of India can create a strong administrative data system to support policies designed to tackle malnutrition.[10] This could be the most reliable way for policymakers to get real-time, on-the-ground information on the nutrition status of its beneficiaries. The urgent requirements are to better train and sensitize those who collect data (*Anganwadi* workers), those who monitor data collection (middle-level officials), and those who use data to make policies (central- and state-level officials) about the potential returns from improving our data quality. Policies that are continuously updated and implemented based on real-time data can be more effective than those that rely on fragmented data, which may be obsolete in dealing with the nutritional challenges of the hour.

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OpeN-Global

An online resource to support the collection of micronutrient status data

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Key messages

- More and better data on micronutrient status are needed to support progress towards achieving a world without malnutrition.
- Data on micronutrient status are lacking from low- and middle-income countries (LMICs); one key barrier to this includes technical support for the assessment of nutritional biomarkers.
- OpeN-Global is an open-access knowledge hub designed to support the objective, accurate and detailed assessment of nutritional biomarkers from populations globally.
- The OpeN-Global platform is designed to support and enable work in populations from LMICs, but the analytical methods presented can be applied to samples from any population group.
- Supporting the generation of quality data in-country will also support evidence-based policy, and help transform outcomes in nutrition and health.

Many readers of the present issue of *Sight and Life* magazine will be familiar with some of the conclusions of the 2018 Global Nutrition Report (GNR):[1] "Data is ever improving but with some basic gaps remaining…There is a significant gap around micronutrients. We do not know the full profile of micronutrient deficiencies across populations, globally."[1] This opportunity is accompanied by a clear call for action: "More essential information and surveillance needs to be gathered to make substantial progress on global targets" (**Figure 1**).[2]

More and better data are needed to support the resolution of malnutrition in all its forms.

Join the discussions on more and better data in nutrition: **#moreandbetterdata**

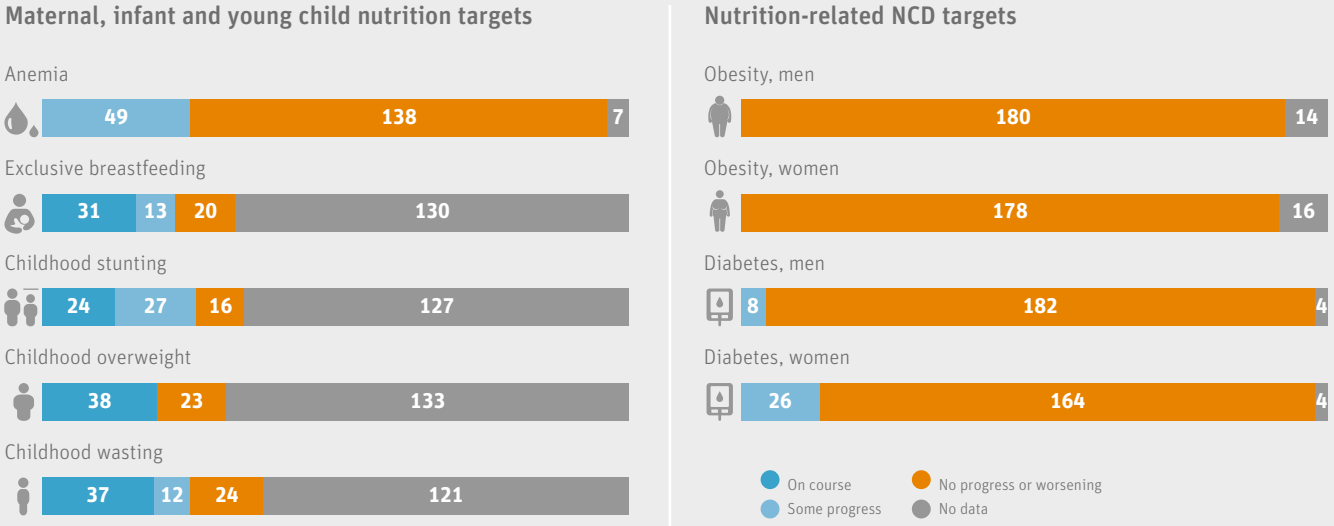
> "Data inform health interventions and public health policy, helping to define research and drive innovation"

Data inform health interventions and public health policy, helping to define research and drive innovation. Robust data prevents the wasting of resources, and promotes better health outcomes in the population concerned. A key barrier to the development of both nutrition-specific and nutrition-sensitive programs and policies, particularly in low- and middle-income countries (LMICs), is a lack of robust data on nutritional status, especially in the most vulnerable groups.

Several key factors hinder the generation of high-quality, accurate and objective data in LMICs. Comprehensive population surveys are labor-intensive and rely on competent, skilled

A laboratory technician scans a barcode in the facilities at MRC Unit The Gambia at the London School of Hygiene & Tropical Medicine (LSHTM). Excellent research infrastructure is not always coupled with adequate training and know-how. Capacity building in these areas will strengthen data outputs across all settings.

FIGURE 1: Conclusions from the 2018 Global Nutrition Report



Conclusions from the 2018 Global Nutrition Report showed that "48% of countries are on track for at least one nutrition target … [but] progress towards targets is too slow."[1] Furthermore, the true state of micronutrient deficiencies in vulnerable populations remains unclear.

manpower, a cold chain and easy access to laboratories with sample-processing capabilities that can handle high-throughput assays on several biomarkers in separate assays. Many laboratories in LMICs have advanced infrastructure. So why are the data from LMIC surveys often limited to anthropometry, single micronutrients or prevalence data?

Through our partner network,[3] which includes leading scientists based in LMICs, we recognized that the key barriers to the assessment of a wide array of nutritional biomarkers are not just a lack of funding and the challenge of collecting human samples. Instead, there is a clear need for guidance and technical support, to capacity build and facilitate laboratory capabilities across many settings. Excellent research infrastructure and laboratory platforms are often in place, but barriers including staff training and technical know-how prevent their full utilization.

Support in these areas would facilitate the assessment of a wider panel of nutritional biomarkers than is currently available and routinely used in population nutrition surveys. This would start a positive cycle of quality control and assurance, technical accreditation, investment and increased trust – leading to better outputs, and more and better data.

What are nutritional biomarkers?

A nutritional biomarker can be described as "a characteristic that is objectively measured and evaluated as an indicator of nutritional status, nutrient-dependent metabolism or function, or biological responses to a nutrition intervention." (*Lindsay H Allen*).[4]

Ideal nutritional biomarkers should be fit for purpose, and be able to confirm or explain clinical symptoms, reflect adequacy or deficiency in nutrient status, and adequately describe a response to any nutritional intervention. They should have a high degree of sensitivity and specificity. Moreover, their use should be feasible, using accessible samples that do not require complicated or sensitive collection or storage conditions and that can be analyzed in an affordable way.

Assessment of nutritional biomarkers can be used to:

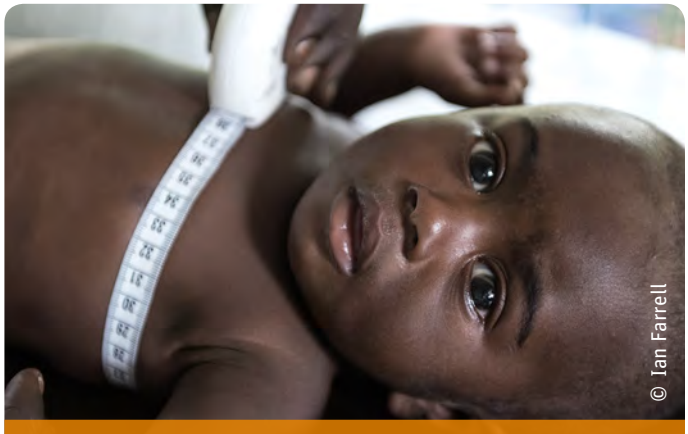
- understand the nutrient status of specific populations, subgroups and, in some cases, individuals;
- confirm dietary intake data;
- propose dietary guidelines, e.g., Recommended Dietary Allowance (RDA);
- evaluate the need for nutrition interventions (supplementation, fortification);
- underpin the design and planning of nutrition interventions;
- evaluate the effectiveness and safety of nutrition interventions; and
- inform basic research.

Pregnant and lactating women and infants are among the vulnerable groups for whom precise data on micronutrient status are often lacking

Our rationale

The importance of high-quality data

The importance of population-based surveys for program and policy development is seen through national programs in high-income settings, such as the National Diet and Nutrition Survey (NDNS) in the UK[4] and the National Health and Nutrition Examination Survey (NHANES) in the USA.[5] These nationally representative surveys provide the quantitative information on nutritional status that is required to identify and address nutritional issues in the population and inform public health policies.



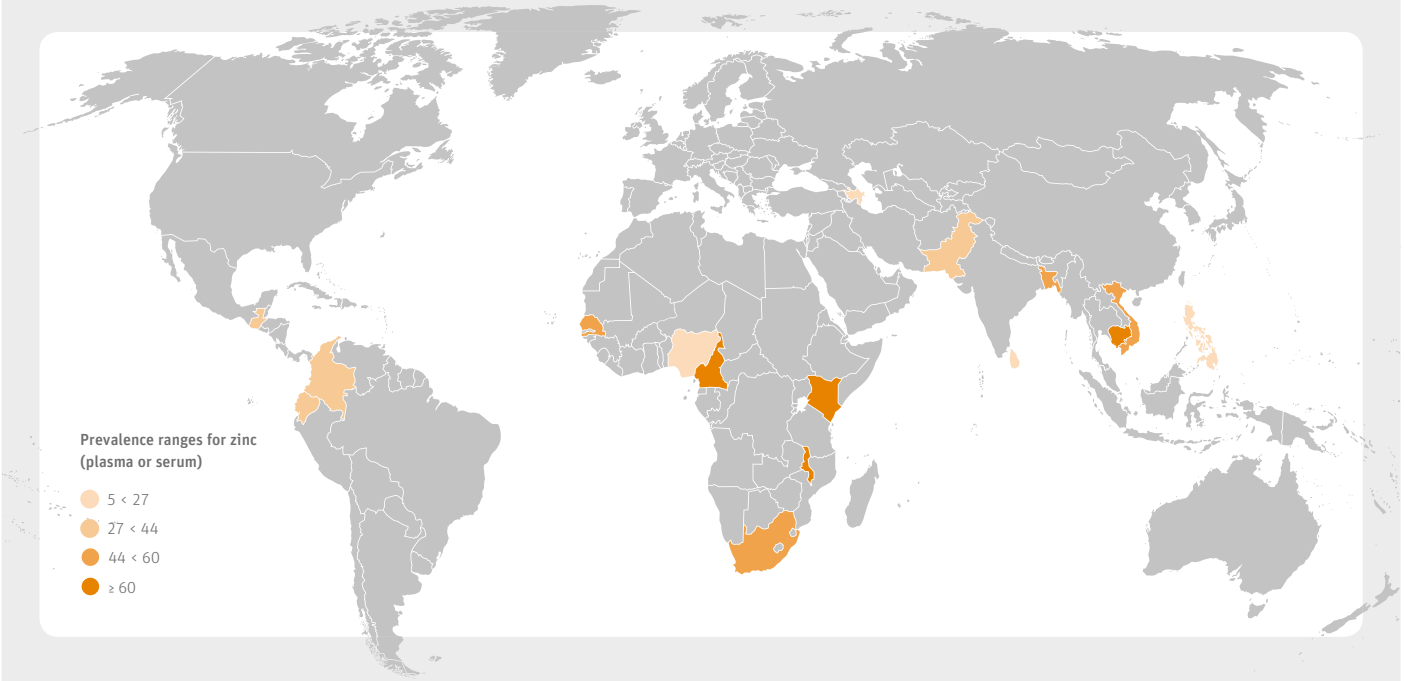
Anthropometry will remain a mainstay in nutrition surveys, but does not give precise information on nutritional status

Many high-quality, population-based surveys are undertaken in LMIC settings. The USAID-supported Demographic Health Surveys (DHS) program and the UNICEF Multiple Indicator Cluster Surveys (MICS)[6] are notable examples. Data generated from these surveys underpin the implementation and success of many health- and nutrition-related activities in LMICs. However, despite capturing data, these surveys rarely include a full and detailed assessment of nutritional status. Data from vulnerable population categories (e.g., infants, children, adolescents, and pregnant and lactating women) are usually limited to anthropometry and easy-to-assay parameters (e.g., hemoglobin).

Proxy markers such as stunting prevalence, household coverage of iodized salt or estimated dietary intake are also included, yet they do not allow a complete understanding of population risk of micronutrient malnutrition. For example, the quality of self-reported dietary data is difficult to guarantee: a review of the literature reporting self-reported dietary intake found that almost half of the studies showed evidence of underreporting, and seven of 16 studies found evidence of overreporting.[7]

Still, there remain concerning data gaps in micronutrient deficiencies (**Figure 2**). The extent of micronutrient deficiencies in all population groups is not fully known – or fully understood. This slows the design of novel and effective interventions, especially for the most vulnerable (see the example in **Case study 1**).

FIGURE 2: Data gaps in micronutrient deficiencies



Only 18 countries have plasma or serum zinc status data from preschool children.
Map generated using the WHO Vitamin and Mineral Nutrient Information System Database.[8]

Today's generation of adolescents is the largest in human history, at about 1.8 billion (2016),[10] and most of them, like these high school students in Herat, Afghanistan, live in LMICs[11]

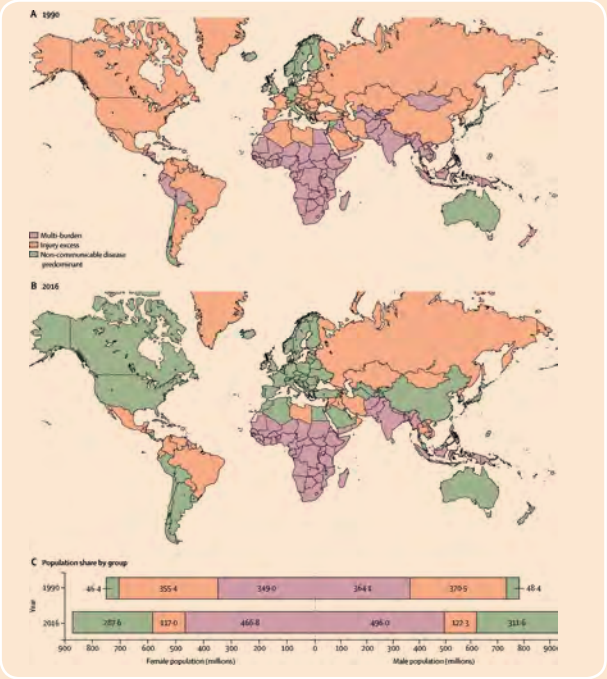
Case study 1: Adolescent nutrition

Adolescence (10–19 years) represents a critical period for growth and development,[9] and therefore an important period beyond the first 1,000 days for targeted interventions to prevent adverse health outcomes in adolescents themselves, their offspring and the next generation.

Shifts in population demography have put adolescents at risk of major nutritional deficiencies, including a 120 percent increase in the prevalence of adolescent overweight or obesity since 1990 (Figure 3).[11]

Despite global research efforts focused on adolescent health,[11] there remains a lack of evidence from robust studies in LMICs to describe the nutritional vulnerabilities within this group.[9] A review on global and regional trends in the nutritional status of young people recognized the need for " objective, comparable and high-quality data,"[12] and this absence of evidence has been cited as a key barrier to the development and implementation of evidence-based nutritional interventions within this age group.[13]

FIGURE 3: Shifts in population demography have put adolescents at risk of major nutritional deficiencies



Adolescent health country groupings in 1990 **(A)** and 2016 **(B)** with population distribution of adolescents in the three groups at both timepoints, by sex **(C)**.[11] Though no country moved back to a 'multi-burden' disease group, there was a dramatic increase in countries with adolescents at risk of noncommunicable diseases.[11]

Case study 2: Policy formulation on micronutrient supplementation in pregnancy

Dietary surveys consistently show that multiple micronutrient deficiencies, rather than single deficiencies, are common among women of reproductive age. It was therefore expected that providing multiple micronutrients (MMNs), rather than iron and folic acid (IFA) alone, during pregnancy could influence maternal and fetal outcomes. This assumption led to the design, by UNICEF, WHO and UNU, of an international multiple micronutrient preparation (UNIMMAP) that provides the RDA of 15 vitamins and minerals.[14] This novel formulation has now been trialed in multiple studies across LMICs, and a recent systematic review of the completed trials "supports the effect of MMN supplements with IFA in improving some birth outcomes."[15]

However, the most recent update by WHO did not alter recommendations beyond IFA.[16] The completed trials mostly took place in LMIC settings, among women with low nutritional status; very few of these studies could include the assessment of the supplement on micronutrient status beyond iron status. It is therefore possible that just supplying enough nutrient to cover a single RDA was not sufficient in these contexts. Certainly, from a single trial in West Africa, the impact of the UNIMMAP formulation on birth weight was only observed when the supplement was given at twice the RDA.[17]

The more recent analysis of individual patient data from these trials was not available at the time of the last WHO update.[18] Greater access to an enhanced evidence base on the nutritional status of this vulnerable group will help support supplement design and policy implementation, and will maximize efficient use of resources.

Administration of a single Recommended Daily Allowance (RDA) of 15 vitamins and minerals may not be enough to cover the nutritional needs of women with a very deficient status

OpeN Global

Open access knowledge hub of Nutritional biomarkers for Global health

www.OpeN-Global.kcl.ac.uk

Created in response to the need for more and better data, OpeN-Global is a hub of resource tools to support the assessment of nutritional status using nutritional biomarkers from human samples in global health settings. OpeN-Global was launched online on 27 February 2019.

Success of health policy relies on adequate monitoring and surveillance

In addition to cohort studies and national surveys, the accurate and detailed assessment of nutritional status is an essential component in assessing the efficacy and impact of trials of nutrition interventions, and the use of these trial results to inform policy (see the example in **Case study 2**). Trials of nutrition-sensitive interventions (such as water, sanitation and hygiene [WASH] interventions) tend to focus on the critical primary outcomes such as child growth and morbidity, with little capacity to assess nutritional status at baseline or following intervention. A greater depth of understanding about the interplay between nutritional status and other factors such as inflammation in these cohorts, in response to interventions and within specific social and environmental contexts, could help in the development of future interventions.

OpeN-Global: a hub of resource tools to support the assessment of nutritional status

OpeN-Global (https://open-global.kcl.ac.uk) is an open-access website specifically designed to support and enable nutrition-focused work in populations from LMICs, but the analytical methods presented can be applied to samples from any population group.[3]

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OpeN-Global aims to support high-quality nutritional biomarker assays across all laboratory settings, and particularly in low- and middle-income countries

OpeN-Global partners attending the kick-off launch in London, UK, in May 2018. In the past year, our network has grown to over 37 committed experts from 20 institutions across 10 countries and on five continents.

The website provides information on the availability of existing nutritional biomarker assays, including laboratory standard operating procedures (SOPs) to download or signposting to published methods. It gives details on quality control and accreditation, provides technical support, and each biomarker fact sheet includes fully referenced general information. OpeN-Global currently covers over 20 nutritional biomarkers, from key nutrients such as zinc and iodine to newer technologies and -omics approaches.

Our 37-strong global partner network of committed academic, technology and industry experts spans 20 institutions across 10 countries on five continents, and provides technical support for the implementation of biomarker assays in laboratories globally, as well as help to interpret the data obtained. Each expert can be contacted via the dedicated OpeN-Global contact page.

> "OpeN-Global is a network of dedicated individuals working to support the collection of more and better data on micronutrient status"

Our vision

OpeN-Global is not just an online knowledge resource, but a network of dedicated individuals working to support the collection of more and better data on micronutrient status. OpeN-Global is therefore also a space for identifying opportunities for developing novel methodologies adapted to LMIC settings, working with academic and industrial partners to develop innovative solutions and, where relevant, developing intellectual property (IP) and allowing further sharing of protocols and methodologies in a multidirectional manner. This partnering of laboratory and technical expertise will also support the training of research staff from LMICs, and will help foster new research collaboration, enabling capacity development in-country. In the long term, it is anticipated that this will enable a greater understanding of the specific nutrition–health relationships across LMIC regions, leading to targeted programs and policies and the associated population health gains.

Acknowledgements

OpeN-Global is a not-for-profit project initiated in 2018 by King's College London and supported by funding from the Medical Research Council (UK) under its 'Confidence in Global Nutrition and Health Research' call as part of a suite of activities under the Global Challenges Research Fund (GCRF).

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The Power of Mobile Platforms for Data Collection

How to leverage them to provide real-time information and insights

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Key messages

- When leveraged correctly, mobile data collection can be a valuable tool for collecting nutrition data remotely from populations that are difficult to reach via traditional methods – an approach that has already been tested by multiple organizations.
- Considerations for incorporating mobile methods into research include: type of technology available, education level and literacy rate, financial and practical barriers to access, and respondent trust.
- Certain mobile-based modes are more appropriate for certain projects – for example, as SMS has character limits, it is best for shorter questions and questionnaires. Voice calls administered via computer-assisted telephone interviewing can collect longer and more qualitative data.

Collecting and analyzing nutrition data in order to develop effective interventions, monitor long-term health outcomes and ultimately reduce the prevalence of malnutrition globally have been a focus of governments and development agencies for decades. In 1974, the United Nations Food and Agriculture Organization (FAO), the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) first developed methods for nutrition surveillance,[1] and nutrition remains a high priority through the Sustainable Development Goals (SDGs), which aim to end global hunger[2] by 2030 through measurable indicators.

However, the practice of collecting the data needed to measure progress has proved difficult for as long as food security and nutrition have been at the forefront of the development conversation. The original Millennium Development Goals (MDGs) were plagued with issues surrounding reliable data[3] from the countries that are most in need of assistance, as low-income countries struggled to provide census data or to invest in gathering data from hard-to-reach populations. This has left it to agencies such as the United Nations World Food Programme (WFP) and FAO, as well as organizations such as CGIAR, to measure progress through data, but these organizations must also balance data needs with budgets and competing country priorities.

One persistent challenge around gathering nutrition data has been the fact that those who suffer the most from malnutrition are often in places that are difficult to conduct research in – including remote areas in Sub-Saharan Africa, conflict zones that are unsafe for researchers to travel to and regions that are inaccessible due to disease outbreak or natural disasters. As mobile connectivity has grown around the globe in the past decade, mobile phones have become an increasingly valuable tool for gathering data remotely from areas that are geographically difficult to reach. Emerging countries now have high mobile penetration rates: recent data from Pew Research revealed that 93% of people in South Africa, 86% of those in Kenya, 83% in Nigeria, 77% in the Philippines and 83% in Brazil own at least a basic mobile phone.[4] In Sub-Saharan Africa as at 2018, overall mobile phone penetration was 45% and smartphone penetration 36%.[5] Penetration rates from low-income countries from 2017 show the differences by country, with Uganda at 41% penetration, Mozambique at 47% and Malawi at 27%.[6] While smartphone and internet penetration rates remain lower, there is clear value in the use of basic mobile technology such as SMS and voice calls to reach people in areas that suffer from food insecurity and malnutrition.

"There is clear value in the use of basic mobile technology to reach people in areas that suffer from food insecurity and malnutrition"

While mobile data collection is a relatively new method for collecting food security and nutrition data, it has already been used with success by multiple agencies. One study by GeoPoll and the WFP conducted in the Democratic Republic of Congo in 2015 demonstrated that food security indicators could be adapted for SMS: mobile-sourced data from the conflict-ridden Kivu region showed that SMS could be used as a high-frequency, low-cost method for data collection.[7] A similar study examined the strengths and limitations of using voice calls, through computer-assisted personal interviewing, to gather nutrition data in rural Kenya, and concluded that dietary diversity scores were not significantly different when comparing data collected via face-to-face modes versus mobile modes; however, other nutrition indicators had somewhat higher averages, indicating less malnutrition, when collected using mobile technology. More research should be done to optimize nutrition questionnaires for mobile, but it is clear that it can be a valuable tool when leveraged correctly.

As more organizations evaluate mobile data collection for nutrition initiatives, there are several factors for them to consider. Below we go into some of the considerations for utilizing mobile phones for nutrition data collection, and how to optimize research studies for the mobile phone.

Considerations for collecting nutrition data through the mobile phone

Choosing the best mobile mode for data collection

One of the first items to consider when collecting data via mobile is the mobile-based mode through which you will conduct research. Mobile devices can be used to conduct surveys through multiple channels, including text message (SMS), voice call and web links viewable on mobile browsers. The most common mobile-based research modes are:

- **SMS surveys:** surveys sent via two-way SMS can reach literate populations with mobile phones and are a less expensive way to conduct research around the globe. As surveys are administered remotely and on a respondent's own device, data can be collected from hard-to-access areas, and privacy concerns may be alleviated without an interviewer being present. Data quality controls in SMS surveys include automatically detecting unusual response patterns such as repeated 'yes' or 'no' answers, putting hidden number ranges in place for range questions and randomizing the order in which multiple-choice answers appear.
- **Voice calls:** voice call interviews can be faster and more cost-effective than in-person interviews as they present fewer logistical challenges around reaching a large number of respondents. As with in-person interviews, voice calls also allow illiterate populations to respond. Quality control mechanisms for voice calls are similar to those used in SMS, and include flagging up unusual response patterns and validating that answers are within an expected range or meet a certain set of criteria. Voice call modes include:
  - **Computer-assisted telephone interviewing (CATI):** trained enumerators place live calls from a remote call center and conduct interviews that can include open-ended questions and more qualitative data.
  - **Interactive voice response (IVR):** an automated system places calls with pre-recorded questions that are answered via respondents keying in numbers on their phone keypads.
- **Online modes:** data can be collected via online modes, which include mobile-friendly links or mobile applications, and link-based surveys sent to desktop computers. These modes are inexpensive but only reach wealthier and more literate populations that have smartphone access; they are therefore a less common choice for reaching low-income populations. In online modes, detailed location data can be collected to verify exact location, in addition to the standard quality control methods mentioned above. Modes include:
  - **Mobile application:** mobile applications require participants to download an application onto their smartphone and use it to take available surveys. This mode allows for advanced features such as location-based questions but requires respondents have a smartphone.
  - **Mobile web:** mobile web surveys are administered through an online link that can be opened in a basic mobile browser. These surveys support video and picture content and require a mobile internet connection.
- **Computer-assisted personal interviewing (CAPI):** face-to-face interviews are one of the most traditional methods of survey data collection, but can be time-consuming and costly. These interviews require enumerator training,

and data is collected via a mobile-based application that guides the interviewer through the questions and allows for answers to be recorded. GeoPoll's CAPI application allows for data validation by tracking the location of interviewers to ensure they are in the expected location and immediately uploading responses to a secure location, and flagging up responses that are entered in and then changed at a later time.

Table 1 is a quick guide that is helpful for differentiating between various mobile survey modes and their respective characteristics. However, consulting with an experienced research agency will provide researchers with more in-depth information on how to conduct nutrition research via mobile.

In addition to mode differences, the following should be considered when conducting nutrition research through the mobile phone.

Technology access and education levels

Although globally mobile penetration is over 67%,[8] smartphone penetration rates are still gaining momentum. The Global System for Mobile Communications (commonly known as GSMA) presented research that shows, as at 2016, that less than 50% of connections in emerging markets are smartphone connections.[9] Rates in Sub-Saharan Africa are even lower. This is an important factor to consider when deciding how to integrate mobile data collection into nutrition research, what populations can be reached using mobile phones and which mobile-based research mode, such as text message (SMS) versus voice call, is most appropriate for a project. While online surveys implemented through links or mobile applications are inexpensive and often readily available, they can only reach mobile phones with an internet connection. For reaching rural areas and lower-income groups, online modes are ineffective. Instead, SMS or voice call surveys, which can reach any handset, should be explored as a more viable option.

> "For reaching rural areas and lower-income groups, SMS or voice call surveys can be a viable option"

TABLE 1: Mobile mode characteristics

Mobile mode characteristics	SMS	CATI	IVR	Mobile web	CAPI	Application
Self-administered	X		X	X		X
Interviewer administered		X			X	
Literacy required	X			X		X
Supports multiple response options	X	X		X	X	X
Complex sampling framework	X	X	X		X	X
Limits to number of questions	X	X				
Able to verify responses		X			X	
Requires a reliable network signal		X	X			X
Cost-effective	X	X		X		X
Immediate data monitoring		X			X	
Suitable on all mobile phone types	X	X	X			
Sensitive questions are applicable	X		X	X		
Limit on the type of questions	X	X	X	X		
Limit on individual question length	X					
Real-time communication		X			X	
Ability to save data	X	X	X	X	X	X
Supports visual aids				X	X	X
Multi-language accessible	X	X	X	X	X	X
Verification of repondents					X	
High response rates		X			X	X
High completion rates		X			X	
High breakoff rates			X	X		

Source: GeoPoll

Women rice farmers using their mobile phones in a paddy field

Literacy rates should also be taken into consideration when evaluating mobile-based research. If literacy rates are low, surveys administered through voice calls are the best remote research method, as they reduce accessibility barriers for participants. For extremely poor regions, mobile phones can be used to gather and upload data collected through in-person interviewers, removing any technological or educational barrier to entry while still offering the benefits of mobile in terms of streamlined data collection and interview tracking.

Financial and practical barriers to entry

When trying to reach people in low-income areas who are suffering from food insecurity and malnutrition, it is important to consider the financial and practical barriers to entry that they may have to overcome in order to be able to participate in research at all. Respondents may not have time to take a long survey during the day when they are working, so consider the time of day you are reaching respondents and whether they might be able to participate at a later time if the original engagement is inconvenient for them.

Incentives should also be provided for participation, whether through airtime credit via a partner with direct connectivity to mobile network operators such as GeoPoll or through mobile money. If a longitudinal study is being conducted, the researcher should consider an incentive that will compensate participants for their involvement in each round and an additional amount for participating in all rounds. This could be through mobile money, airtime credit or cash in the case of an in-person interview. To reduce the cost of participation, certain mobile platforms including GeoPoll are able to send surveys through 5–6 digit codes known as shortcodes, which do not incur costs when responded to, so that anyone can receive and respond to messages, even if they have no airtime in their account.

Privacy concerns and respondent trust

Hunger and malnutrition can be a sensitive topic, especially when questions are being asked about children, who are often the focus of nutrition studies. Guidelines covering research with children set by organizations including the American Association for Public Opinion Research (AAPOR)[10] state that parental consent should be provided and that children should be involved in the decision-making process when practicable. When surveying via mobile phone, this may mean extra messages, with the appropriate language built into the questionnaire.

In addition, survey participants may have privacy concerns around what the data collected is being used for, and they may not want to answer questions directly to another person due to the stigma surrounding hunger. Remote mobile data collection can address some of these privacy concerns, as surveys are administered in a participant's own home, at the time of their

Example of an SMS survey on a basic mobile phone

choosing, and questions are answered through their own mobile phones, which provides more anonymity than an in-person interview. In the case of SMS, respondents do not have to speak to anyone, allowing them to feel even more safeguarded from judgment.

Ensuring that potential respondents view the company conducting the survey as reputable and trustworthy will improve response rates and data quality. Using the name of the organization or conducting surveys is a good way to build trust and can help response rates, especially if it is a well-known academic organization or nongovernmental agency. Depending on the study's goals, organizations often do not reveal their identity in order to reduce bias, and working with a third-party provider that is trusted locally, such as GeoPoll, ensures unbiased results. Because GeoPoll's system is directly integrated with mobile networks around the globe, incentives from GeoPoll surveys are immediately deposited into a respondent's account, providing them with reassurance that the promised incentives will be paid out.

Interview length and wording considerations for mobile

Because mobile interviews are deployed remotely, clear, concise wording results in survey respondents doing less guess work and increases the accuracy of the collected data. Several food security and nutrition indicators have been adapted for mobile to achieve this goal. Survey fatigue is also a concern when developing questionnaires for mobile phones, and length should be considered. Longer surveys can be split into multiple questionnaires or offset by higher incentives.

Questions must be written for the technology that they will be viewed on. Each question for an SMS survey must be 160 characters or fewer, including the full question and the respective list of response choices. This makes SMS an ideal mode for shorter surveys and questions that can be cut down. Voice calls, in particularly CATI, in which trained enumerators administer interviews, are a good mode for longer questionnaires because of the way in which the survey is conducted. In addition, voice calls can collect more qualitative data than SMS surveys, which can ask open-ended questions but typically get less detailed data back.

> "Mobile research is most suited to projects that allow for remote data collection"

Conclusion

Mobile research is most suited to projects that allow for remote data collection, and it often requires that organizations have the flexibility to adapt a questionnaire for the mobile phone. Extremely long questionnaires and projects that require a large amount of qualitative data collection may not be as suited for mobile as shorter, primarily quantitative surveys. As more organizations utilize mobile-based research, it is imperative that they share findings in order to add to the knowledge base around how to best implement mobile research. By doing this, we can ensure that mobile continues to grow into a sustainable method of high-quality data collection.

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About GeoPoll

GeoPoll is a leader in providing fast, high-quality market research from areas that are difficult to access using traditional methods, and conducts over 10 million surveys per year through the mobile phone. Working with partners including NGOs, academic groups, media houses and brands, GeoPoll facilitates projects that measure vital indicators.

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Open Data for Nutrition: A Strategy

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Key messages

- Open data has the potential to improve nutrition-based research by effectively increasing the ability to access and use a greater range of data on the part of actors from a wide range of sectors.
- This calls for focus on a *food systems* approach that can help link agriculture and nutrition outcomes. All the elements and activities that relate to the production, processing, distribution, preparation and consumption of food can be drawn together to deliver impact.
- At the heart of a new open data policy for nutrition is a consensus statement or charter that research funders can publicly sign up to, providing a tangible commitment that can be shared with all stakeholders.

Overview

Global Open Data for Agriculture and Nutrition (GODAN) and the Need for Nutrition Education / Innovation Programme (NNEdPro) are developing a Nutrition Open Data Strategy. This strategy aims to provide a method of gaining agreement across organizations that collect and generate nutrition data across the entire food system, with a view to making this data available and openly accessible to other researchers and practitioners.

The maximization of data availability to nutrition and agriculture practitioners, drawn from a variety of audiences and sectors, will help towards achieving the United Nations Sustainable Development Goals (SDGs), improving food security and nutritional health and wellbeing.

A workstream needs to be undertaken to develop a strategy that will provide clear guidance to producers and users on what open data practices should be followed. This will underpin the production of a consensus statement, or charter, that publicly commits organizations and researchers to share their data openly. Work needs to be undertaken on developing a common vocabulary, while stakeholder opinion and the challenges and opportunities need to be fully identified.

A working group will develop the strategy for consultation, ahead of developing a consensus statement or charter for organizations and researchers to sign up to.

> "This strategy aims to provide a method of gaining agreement across organizations that collect and generate nutrition data across the entire food system"

The need for an Open Data Strategy

The Food and Agriculture Organization of the United Nations (FAO) estimated that between 2011 and 2013 one in eight people in the world suffered from chronic hunger. At the same time, the percentage of the population who were undernourished had decreased by 17% compared with 1990–92.[1] The changing nutrition landscape has led to a shift in diet-related epidemiology, which has been primarily characterized by the coexistence of undernutrition with overweight and obesity, also known as the double burden of malnutrition. Achieving food and nutrition security and addressing the double burden of malnutrition have been identified in the UN SDGs.[2]

In terms of agriculture, the sector is under pressure to provide food to meet the needs of a growing population while facing issues such as the degradation of fertile land, the drying up of water resources, the disappearance of genetic resources and climate variability. These, in turn, will have an effect on the nu-

Environment concept 'Green Planet'

trient content of the food grown. Price volatility also has a disruptive effect, particularly on vulnerable populations.

With increased amounts of data collected across the food value chain, open data offers the potential to improve food production, nutrition and the delivery of information to users. Open data will not of itself replace expertise in the sphere of nutrition; however, ensuring the data is produced in a manner that is understandable and accessible will empower decision-makers, entrepreneurs, health professionals and consumers to make better choices along the chain. Apps and related technological platforms will need to be put in place to ensure cross-sector actors are able to access the tools they need to enable them to make better decisions.

The Global Nutrition Report 2018[3] identified the main issues with regard to nutrition, confirming that the absence of accessible and usable data remains a fundamental barrier to improving nutrition.

"The absence of accessible and usable data remains a fundamental barrier to improving nutrition"

Collective aim

The GODAN–NNEdPro Nutrition Open Data Strategy aims to be a game-changer, creating the necessary environment for organizations that collect and produce nutrition data to make data openly available and accessible to other organizations and researchers. Maximizing the availability of data will be useful to nutrition and agriculture practitioners working to achieve the UN goal of ending hunger and all forms of malnutrition by 2030.

The strategy development partners

The two partners involved in the development of this strategy provide distinct yet complementary skill sets in the field of open data for nutrition to the project.

GODAN (Global Open Data for Agriculture and Nutrition)

By supporting global efforts to make agricultural and nutritionally relevant data available, accessible and usable for unrestricted use worldwide, GODAN is helping to deal with the urgent challenge of global food security. It is a rapidly growing network, comprising more than 900 partners from national governments as well as nongovernmental,

international and private-sector organizations that have committed to this joint statement of purpose.[4]

The initiative focuses on building high-level support among governments, policymakers, international organizations and businesses. GODAN promotes collaboration to harness the growing volume of data generated by new technologies, to solve long-standing problems and to benefit farmers and the health of consumers.

NNEdPro (Need for Nutrition Education Project)

NNEdPro is a think-tank, academy and knowledge network. Its mission is to develop a critical mass of knowledge, skills and capacity in nutrition and health, within the healthcare and public health workforce, resulting in improved health practices and outcomes.

The project has evolved to become the Global Centre for Nutrition and Health, focusing on developing adaptable and scalable models for medical nutrition education, combining clinical and public health knowledge with leadership training to aid implementation in healthcare settings.

André Laperrière, Executive Director of GODAN

GODAN
Global Open Data
for Agriculture & Nutrition

The role of nutrition in achieving the UN Sustainable Development Goals (SDGs)

Both GODAN and NNEdPro are interested in the ability of data to improve human health, and believe the best way to achieve this is through open data. However, more research needs to be undertaken into successful interventions to fully understand how open data can best support progress.

Nutrition underpins all of the UN SDGs, and both organizations involved in the strategy believe that a practical food systems approach will deliver concrete and practical global nutrition outcomes (**Table 1**).

> "Partnerships are key to improving nutrition"

Food security as a component of nutrition security

When we talk about feeding the planet, and our ability to adequately feed an estimated 9.7 billion people by 2030, we often discuss agricultural production as the means to achieve food security. Yet, 2 billion people consume excess calories – often in the form of energy-dense food – while consuming a diet that may contain either a deficiency or an excess of specific dietary components, thereby failing to meet their nutrient needs.

At the 1996 FAO World Food Summit, food security was defined in the following terms:

> *"Food security exists when all people, at all times, have physical, economic and social access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."*

The focus on the word 'sufficient' implies that humans have the right amount of food, which can be interpreted as having neither too little, nor too much. From a nutrition standpoint, the International Food Policy Research Institute (IFPRI) described the food security crisis by placing the food-insecure population into three broad categories: **(1)** too many calories, and for many, not enough nutrients; **(2)** sufficient calories, not enough nutrients; and **(3)** too few calories, not enough nutrients. IFPRI has termed these factors the 'triple burden of malnutrition'.[5] It is clear to see from these three categories that food security is not simply an issue of calories, but also one of nutrients and diet quality.

However, 'nutrition security' also requires nonfood factors, such as clean water and a safe environment, so one can consider a hierarchy: nutrients contribute to food security; and food security contributes to nutrition security.[6]

GODAN has aligned its efforts with SDG sub-goal 2.1,[7] to "end hunger and ensure access by all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round," linking to the 1996 FAO World Food Summit term of "sufficient".

A food systems approach

Agricultural systems are under pressure to provide adequate nutritious food while coping with depleted water resources, the degra-

TABLE 1: Nutrition link to the Sustainable Development Goals from the SUN Movement Report

Sustainable Development Goals	Nutrition link from the SUN Movement Report[5]
01 **No Poverty**	Being poor limits the ability of individuals to access adequate food.
02 **Zero Hunger**	Agriculture and food security are cornerstones of nutrition, and good nutrition supports productive lives.
03 **Good Health and Wellbeing**	Up to 45% of deaths in children under 5 are caused by undernutrition.
04 **Quality Education**	Learning and focusing in school is difficult without a sufficient diet, as good nutrition drives up IQ levels.
05 **Gender Equality**	When women control the family income, children's health and nutrition improve at a greater rate.
06 **Clean Water and Sanitation**	Access to safe water and sanitation is an absolute prerequisite for nutrition, with 50% of malnutrition linked to poor sanitation.
07 **Affordable and Clean Energy**	Essential for producing food and thus nutrition.
08 **Decent Work and Economic Growth**	0.9% of GDP is lost to iron deficiency alone. High levels of malnutrition in some countries may result in 11% loss to GDP.
09 **Industry, Innovation and Infrastructure**	Essential for innovations to improve nutrition.
10 **Reduced Inequalities**	Almost 50% of countries experience malnutrition.
11 **Sustainable Cities and Communities**	Malnutrition is widespread in slums and shanty towns.
12 **Responsible Consumption and Production**	Tackling resource use and degradation is key to sharing resources, improving access to quality food and stabilizing food prices.
13 **Climate Action**	Climate change may reduce food production and cause water scarcity. Seasonal effects also influence nutritional status.
14 **Life Below Water**	Healthy dietary choices can be good for the planet and nutritional intake.
15 **Life on Land**	Soil degradation threatens our ability to grow food, and sustainable food production can improve nutrition.
16 **Peace, Justice and Strong Institutions**	War and conflict are major underlying factors of nutrition insecurity. Ending malnutrition supports stable societies.
17 **Partnerships for the Goals**	Aid allocated to nutrition has high returns. A US$1 investment in nutrition has demonstrated a US$16 return in economic growth. Partnerships are key to improving nutrition.

Source: 2016 SUN Movement Annual Progress Report

dation of fertile land and climate variability among other issues, all of which have an effect on the nutrient content of the food grown. The context is different in every country, and data needs to be collected at national and subnational levels to understand and monitor the situation within the relevant country and compare across countries. This data needs to be made available so that it can be widely utilized, particularly in cross-country comparisons.

One of GODAN's core goals is to tie agriculture to human nutrition through the effective use of data interoperability and integration. A *food systems* approach is a well-researched method to support the link between agriculture and nutrition outcomes. It includes all the elements (environment, people, inputs, processes, infrastructures and institutions) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socioeconomic and environmental outcomes.[8] (The *food supply chain* is a component of the food system, consisting only of the activities and actors that take food from production to consumption and to the disposal of its waste).[9]

In adopting a food systems approach, the open data nutrition strategy links to the three pillars of sustainability – economic, environmental and social – in relation to value chain

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A farmer using tablet computer analysis data in a field under cultivation

activities. This is required because a simple drive to increase nutrients could produce adverse consequences, such as further soil erosion, increased environmental damage or reliance on limited and harmful diets. Therefore the strategy must encourage wider aspects of research, reflecting the entire production, manufacturing and distribution processes involved in the delivery of better diets.

Open data in the food system is essential for effective decision-making and resource efficiency. A food systems approach, underpinned with high-quality open data, provides greater understanding of all the factors involved.

GODAN–NNEdPro Open Data Strategy

The project aims to bring together partners to determine:

1) types of data being produced and used;
2) opportunities and challenges involved in making data openly available;
3) development of standard guidelines for open data; and
4) development of an Open Data Strategy Charter to encourage partner involvement.

Open data

Open data is data that anyone can access, use or share.[10] Such access to data can help shape solutions by enabling effective decision-making while driving organizational transparency. A strong data infrastructure requires that different datasets can communicate with each other, and adherence to common open data standards can help. A data standard is a guideline or series of guidelines that defines the way in which data should be collected or structured. By following the standard, similar data can be easily compared over time, across locations and within and between organizations, as well as being easily manipulated to help identify trends. In other words, standards simplify data reuse.

Regarding the proposed project, the data strategy and consensus statement or charter needs to engage stakeholders within the agriculture and nutrition research, funding and practitioner communities.

Project results and analysis

Spectrum of nutrition data

In preparation for a workable approach, a systematic review of the keywords used to describe the food system across the spectrum of nutrition was undertaken. It covered sectors including agricultural production, processing, storing, transportation, retailing and consuming, taking into consideration the psychosocial context in which food is considered and valued.

Stakeholder engagement

During the 2017 NNEdPro International Summit on Medical Nutrition Education and Research, presentations were provided on the wider determinants of health outcomes. This included such assertions as the need for policymakers to be able to recognize that access to open data can support policy decisions in agriculture, and the potential for food systems to bridge the gap between food production and nutrition.

Participants observed that there was a strong case for an intersectoral approach. Determinants – including heredity, environmental and other nondietary aspects of lifestyle such as socioeconomic factors – impact dietary choices. The ability to plan intervention pathways was also a factor. Manufacturers need to alter food production and to provide better nutrition education.

Discussion of project findings

The work undertaken so far has determined the following foundational factors for an open data nutrition strategy:

- **Challenges to opening, using and reusing data**
  Open data can lead to the potential increase in the use of data. However, the data is not always being used for the purpose it was originally intended, which can adversely affect interpretations.
- **Repositories**
  Existing open data repositories can be better publicized, ensuring that potential users are aware of the existence and availability of such data sources (see examples in **Table 2**).
- **Timely and accessible**
  Data needs to be made open as a priority as soon as possible after reports or scientific publications are completed, to ensure timeliness of availability.
- **Discoverable**
  Users need to be able to find relevant data. Potential users could be informed of the existence or release of the data. Recording studies in a repository enables researchers to be aware of the existence of other studies being undertaken.
- **Interoperable**
  Interoperability is the ability of systems and services that create, exchange and use data to have clear, shared vision for the contents, context and meaning of that data. One-off approaches to data are likely to have hidden costs and thus further impact on the usability.

TABLE 2: Examples of data repositories and registries

Registry	Study types	Cost
ISRCTN registry[11]	All clinical research studies	GBP 226 (+VAT, when applicable)
ClinicalTrials.gov[12]	Clinical trials and observational studies assessing biomedical and/or health outcomes	Free
AgTrials[13]	Trials, mainly of plant varieties, but includes agricultural technology for farmers in the developing world	Unknown – appears free
Agricultural Data Collection[14]	Farmer-centric data repository	US$24.95 per month

> **Comprehensive**
Data needs to be published in a way that makes it easy to find and easy to understand what it contains. It should be accompanied by supporting information about how the data is collected and what it can be, or has been, used for.

> **Data ownership, acknowledgement and protection**
Open data creates challenges around data ownership, particularly of personal data, while at the same time opening research opportunities and driving commercial use. The terms of reuse, including citations of the data, should be clear.

> **Data protection and ethical considerations**
Research data is collected and processed after a process of ethical approval. Any use of data should adhere to the ethical standards and approvals granted for the original study.
The process of informed consent needs to be considered so as to ensure that the data can be made openly available within the constraints of what the owner consented to.

> **Confidentiality**
In order to maintain confidentiality, all data will be anonymized before making it open, with a mechanism to report any identified issues to the primary data holder. However, as anonymization can be resource-intensive, an efficient way to manage and accomplish this needs to be identified.

> **Data quality**
Data and its quality can vary by organization. The gaps in data will need to be clearly articulated, and consideration should be given to developing a feedback mechanism with a view to improving the quality of data.

> **Data maintaining**
When data is opened, it should be made clear whether it is a one-off project or whether the data collection is done on a continual basis. If data continues to be collected, a planned timeline of when the datasets will be updated should be provided.

> **Data collection with intent to open**
If funding depends on open data, are there ways of finding out how to make open data work? How much would practice change if research and project funders required data to be open? Seeking commitment from funders to make this a component of funding agreements could significantly advance their particular area of work and the availability of data.

> **Standards and metadata**
Questions remain as to which standards should be used. As the real value is in the metadata, guidance should be provided to all parties on what metadata to include and on how to do this, particularly for those performing small-scale research.

Next steps in development and implementation

Creation of a GODAN–NNEdPro Open Data Nutrition Working Group

GODAN led a Nutrition Data Gaps Working Group in 2016, which resulted in the release of the Branded Food Products Database[15] at the 2016 GODAN Summit[16] in New York City. Capitalizing on this experience, GODAN will form a Working Group to develop a Nutrition Open Data Strategy. This Working Group, which will cover the entire nutrition spectrum, will include representatives from governments, universities, NGOs and the private sector.

Terms of reference

Membership is proposed to consist of delegates from the following groups:

> the nutrition and agriculture research communities;
> policymakers from the fields of public health, international health development, agriculture and sustainability;
> information technology, artificial intelligence and data systems architecture experts, researchers and private-sector representatives;
> funding bodies;
> end users;
> intersectoral representation from industry, government, academia and the not-for-profit sector; and

> journals and publishers.

The Working Group will act in an advisory capacity to assist a project team to create a strategy and consensus statement or charter that will be both ambitious and realistically implementable.

"The goal must be achievable and realistic, but also beneficial to all parties, in order to obtain agreement"

Open Data Consensus Statement / Charter

Developing a consensus statement, or charter, that partners and research funders can publicly sign up to is a means of gaining tangible agreement and commitment among all stakeholders, researchers and practitioners.

The goal must be achievable and realistic, but also beneficial to all parties, in order to obtain agreement. Using the information already collected and input from the Working Group, the consensus statement or charter and its supporting strategy must contain clear guidance. In addition to consensus on the principles of open data-sharing, there needs to be agreement concerning a potential multilevel support and capacity-building solution along the broad outlines proposed by GODAN and NNEdPro.

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Dalili and the World Food Programme

Smartphone-based data curation to put affordable, nutritious food on the plates of the world's most vulnerable

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Key messages

- Dalili – 'my guide' in Arabic – is a smartphone app that allows anyone in Lebanon to compare the prices of 250 staple foods in local shops using the phone's GPS function.
- Users can also compile shopping lists, as well as leave anonymous feedback to help shop owners improve their stores.
- The solution has been developed by the World Food Programme (WFP), together with its Innovation Accelerator in Munich and Retail team at the Country Office in Beirut.
- For WFP, which provides 700,000 Syrians and 50,000 Lebanese with cash to buy food each month, Dalili means that affordable, nutritious food is even more accessible.

Bargain-hunting from the comfort of home

In the quiet village of Qabb Elias, in eastern Lebanon, Muna sits on her porch swiping through the World Food Programme (WFP)-supported smartphone application, Dalili, with her young daughter Lamar. Just a day away from her monthly WFP cash assistance top-up, Muna prepares a grocery list – a ritual familiar to her, from her life back in Syria – but now using Dalili. Bargain-hunting from the comfort of her home, Muna relies on the app to help her save money as she shops for nutritious food for her family.

"One time, I found 4,000 Lebanese pounds [US$2.66] savings on milk," says Muna. "That's enough to buy four bags of pasta and to make four dinners for my family."

On the other side of the economic coin, Omar is the owner of the thriving Al-Hayek shop in Qabb Elias, across the street from an informal Syrian refugee settlement where many WFP beneficiaries live. But things weren't always so good.

"The store was a mess before we began working with WFP," says Omar. "I didn't take advantage of the space and there was little variety in products." With help from WFP's retail team, specializing in one-on-one shop consultations on layout and product assortment, Omar was able to transform Al-Hayek into a thriving family business. And thanks to better organized aisles, more diverse products and a greater emphasis on Syrian brands, business is booming. Now, Omar uses Dalili as free advertising for monthly promotions. A recent special of two free packs of pasta with every purchase of a can of tomato paste brought a large number of customers through his doors.

Finally, there is Miriam – a grandmother whose favorite time of day is when the sun is setting and three generations of her family are gathered under a single roof for a meal she chose and prepared. During the holy month of Ramadan, these moments are even more special to Miriam, whose heart warms as her sons arrive for the daily fast-breaking of *iftar* (the evening meal with which Muslims end their daily Ramadan fast at sunset). "It feels good to walk to the shop to provide for my family," she says. As a long-time customer of Al-Hayek, Miriam has seen her own life improve in parallel with the quality of the shop. Now, she has better access to food that makes her feel in control and at home – food that brings people, and families, together.

Browsing through Dalili helps Muna make smart choices on how to spend her World Food Programme assistance

"It feels good to walk to the shop to provide for my family"

Dalili – 'my guide'

Every human depends on food for survival.

The requirement for daily nutrition is a common trope among the world's myriad cultures. Access to adequate, nutritious food to live a healthy life is one of the pillars of food security, upon which humanitarian organizations are often founded. For socioeconomically vulnerable families, that pillar is often not strong enough to support a healthy, nutrient-rich diet and lifestyle.

Lebanon, which borders Syria to the west and the Mediterranean Sea to the east, hosts around 1.5 million Syrian refugees, many of whom are food-insecure. There are also entire swathes of local populations who are often unsure of how they will pay for their next meal. One innovative solution for making families' limited dollars – or Lebanese pounds – go a little further has been developed by WFP, together with its Innovation Accelerator in Munich and Retail team at the Country Office in Beirut.

Dalili – 'my guide' in Arabic – is a smartphone app that, with a few taps, allows anyone in Lebanon to compare the prices of 250 commonly consumed foods in local shops using the phone's GPS function. Users can also compile shopping lists, as well as leave anonymous feedback to help shop owners improve their stores (**Figure 1**).

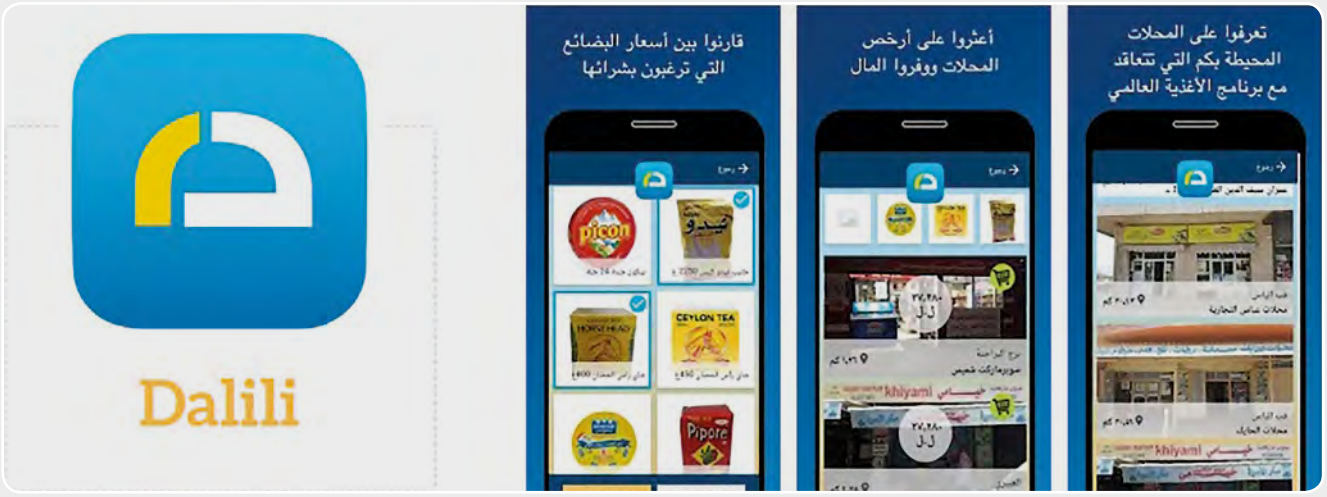
"Dalili means that affordable, nutritious food is even more accessible"

For refugees who have traditionally obtained food via a standard but basic basket in distribution lines, receiving assistance via cash-based systems means the freedom to purchase the items necessary to create meals that connect families to cultural identities, and teach children the flavors of home. But perhaps more critically for WFP, which provides 700,000 Syrians and 50,000 Lebanese with cash to buy food each month, Dalili means that affordable, nutritious food is even more accessible.

Helping price-savvy shoppers

Dalili launched in 2017 with the aim of helping price-savvy shoppers. But WFP has also leveraged its technological know-how to

FIGURE 1: Screenshot: Google Play App Store



Dalili was designed by the World Food Programme in collaboration with its Innovation Accelerator, to help the people it serves to find the most affordable and nutritious food available

collect data from those shoppers and send it back to shopkeepers. Now, WFP's expert retail team, spread throughout Lebanon, is giving 450 contracted shops tutorials on how to improve their stores, by offering deals to customers and tailoring their produce to their clients' demands. Those shopkeepers even have their own app that supports Dalili, called Matjari. Using this app, they can amend prices, scan their competitors' deals and keep abreast of their customers' shopping habits.

As one Syrian shopper explained, "Before Dalili, shop owners used to tell us 'This is how it is.' But now we know that they pay attention to our feedback, and make sure prices are displayed and items are correctly packaged." Another person raved, "This is what we've been yearning for: power in our hands. Capacity to choose where to get the best prices and tell WFP how we've been served by the traders."

Omar has benefited from WFP support in improving the layout and assortment of his shop

> "This is what we've been yearning for: power in our hands"

Finding nutritious food, living healthy lives

While Dalili has already proven its value in Lebanon, growing to over 20,000 users in 2018, now is the time to bring its impact to even more people. WFP is also rolling out Dalili in Jordan and piloting it in the Kakuma refugee camps in Kenya. The team's innovators are currently adding personalized information, such as promotion opportunities specially adapted to specific users, and including the capacity for a user to see their account balance and most recent transactions, in order to optimize the benefits provided to those who rely on it the most. The long-term ambition is to provide, through this application, all the information required by WFP cash recipients to use their assistance to find nutritious and affordable food and continue to live healthy lives.

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Leveraging Disruptive Technologies for the Mid-Day Meal Program in India

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Key messages

- The Indian Government's Mid-Day Meal (MDM) Scheme is known for being the largest school-lunch program in the world. The Akshaya Patra Foundation (TAPF) supports this scheme by feeding over 1.76 million children every school day.
- Recently, TAPF deployed technology to enhance the efficacy of this program in its bid to eliminate classroom hunger in India.
- Accenture and TAPF's Million Meals pilot leveraged technology such as artificial intelligence (AI), the Internet of things (IoT) and blockchain to improve the program's efficiency.

Mid-Day Meal Initiative of the Government of India

The Akshaya Patra Foundation (TAPF)'s support of the Government of India Mid-Day Meal (MDM) Initiative, serving wholesome, safe and tasty meals to over 1.76 million children in India, is known to be the largest NGO-run school-lunch program in the world.

For the past 18 years, the organization has strived to continuously leverage technology to scale its reach to millions of children across the country. TAPF's 41 centralized kitchens serve hot, safe, nutritious and tasty meals every day to schoolchildren in 12 states of India. Its operations are reliant on state-of-the-art technology that is equipped to prepare thousands of meals in just a few hours, while ensuring safe handling, preparation and delivery of the food.

In 2017, TAPF collaborated with Accenture to test technologies that could further improve the operational efficiency and overall output of its school-lunch program. Tech4Good is a program set up by Accenture Labs with the objective of solving complex social problems through the use of innovative technologies. In collaboration with this program, TAPF launched a pilot initiative in Bengaluru, Karnataka – the Million Meals Project. The Million Meals Project was aimed at significantly extending TAPF's service reach by improving its supply chain and operations while maintaining the high quality standards held by the organization. In order to achieve these objectives, disruptive technologies such as artificial intelligence (AI), the Internet of things (IoT) and blockchain were introduced as part of the project.

> "TAPF's operations use state-of-the-art technology that is equipped to prepare thousands of meals in just a few hours"

Implementing the Million Meals Project

The pilot was implemented over 6 months. The preliminary analysis of the pilot showed that it was feasible to improve the efficiency of the program by 20 percent, and that this could significantly boost the number of children served nutritious meals. The project was initiated with a strategic assessment, followed by the development of a prototype by Accenture for improving kitchen operations and outcomes. AI, IoT and blockchain were then applied to four critical processes:

1. monitoring meal production;
2. tracking food delivery;
3. collecting school feedback; and
4. measuring the quantity of food and supplies to be purchased.

Feedback from children and schools moved from manual collection to a more efficient technology-based solution – the use of handheld devices. This, in fact, enabled multiple stakeholders,

Akshaya Patra meals being served to Government schoolchildren

such as parents, teachers and the School Development and Monitoring Committee (SDMC), to give their feedback in real time.

Furthermore, using blockchain and sensor-enabled devices, and leveraging AI technologies, the indent for the next day's meal requirements could be gathered digitally, which allowed for prompt and immediate data collection.

The timelines of food delivered to each school were tracked and the data was collected using mobile devices and a system built by Accenture. IoT sensors were used to monitor the cooking process, to ensure optimum energy consumption and consistent food quality. This system helped to track kitchen performance and provided accurate, real-time data to make better-informed decisions that saved valuable time and effort.

> "IoT sensors were used to monitor the cooking process, to ensure optimum energy consumption and consistent food quality"

As a part of this project, real-time temperature sensors were installed in every cauldron – the temperature data was captured automatically on a central server – eliminating the need for manual data capturing and digitization, which had previously taken about 10 minutes of reading time.

Through a temperature-monitored cooking process, cooking cycles were monitored and controlled precisely to prevent undercooking or overcooking of the cooking batch. This also ensured enhanced efficiency of meal production, as seven additional batches of meals could be cooked during the time saved.

The Akshaya Patra kitchen process

Akshaya Patra food packing for schools

TAPF and Accenture's Million Meals pilot demonstrated how technology such as AI, IoT and blockchain could help to enhance preparation operations and, therefore, expand production processes and improve audit capabilities, attendance recording, order and data collection, and food capabilities.

The use of these technological innovations not only helped TAPF establish a template for operating other kitchens but also revolutionized its supply chain and operations, resulting in improved food quality and extended service reach.

"These technological innovations helped TAPF establish a template for operating other kitchens and revolutionized its supply chain and operations"

About The Akshaya Patra Foundation

Akshaya Patra is a not-for-profit organization that strives to address classroom hunger and bring children to school by implementing the Mid-Day Meal Scheme in Government and Government-aided schools. Since 2000, the Foundation has worked towards reaching more children with wholesome food on every single school day. The Foundation is continuously leveraging technology to cater to millions of children. Its state-of-the-art kitchens have become a subject of study and attract curious visitors from around the world.

In partnership with the Government of India and various State Governments, and the inestimable support of many philanthropic donors and well-wishers, Akshaya Patra has grown from humble beginnings, originally serving just 1,500 schoolchildren across five schools. Today, Akshaya Patra's Mid-Day Meal Program is the world's largest (not-for-profit-run) school-lunch program, serving wholesome food to over 1.76 million children from 15,024 schools across 12 states in India.

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Data-Driven Nutrition in the Digital Age

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Key messages

- There are more than 325,000 health apps available in app stores, which consumers are using to monitor and evaluate their individual health outcomes.
- New innovations, such as Farmwave's pest and pathogen diagnosis app, are being applied across the food supply chain to support the growth, distribution and affordability of healthy, nutrient-dense foods.
- Independent and locally based mobile markets and online shopping platforms are cropping up to improve food access by delivering groceries directly to food-insecure communities.
- Machine-learning algorithms are being used to aggregate data from supermarket loyalty cards in order to generate coupons for nutritious foods and to offer personalized diet recommendations based on consumers' shopping habits.
- Data-driven technologies are being employed across the entire food system both to influence individual behavior change and to address inefficiencies across the food supply chain.

Introduction

Today, data-driven technologies are being used to improve nutrition and health outcomes at the individual level and on a global scale. For individuals, there are now hundreds of thousands of mobile health (mHealth) apps available for download in global app stores related to fitness, diet or medical health.[1] While more research is needed to evaluate their overall effectiveness, these diet and nutrition apps are playing a growing role in supporting individual health-related behavior change.[2] In an effort to address nutrition and health at scale, emerging technologies are being adopted to transform the entire global food supply chain to ensure nutritious food is grown more sustainably and distributed more equitably.

> "Diet and nutrition apps are playing a growing role in supporting individual health-related behavior change"

From image-recognition tools that can identify plant diseases and pests within a matter of seconds and traceability technologies that increase transparency across the food supply chain, to data-driven nutrition apps that employ machine-learning algorithms to track dietary intake and make personalized recommendations to support better individual health outcomes, emerging technologies are being adopted to improve nutrition in the USA and around the world. With the world's population expected to reach nearly 10 billion by 2050, these technical solutions may play an important role in helping to solve some of the most pressing global environmental and agricultural challenges. To better understand how agriculture, food and nutrition data can be leveraged more effectively in the US food system and spur innovations in data-driven technologies across the food supply chain, Google recently brought together more than 35 experts working across the US food system to form the Refresh Working Group. The group is dedicated to ensuring the positive application of new technologies and artificial intelligence (AI) systems with the goal of nourishing the nation and, ultimately, the planet. In this article, we explore how innovations in digital technologies are being applied to change eating habits and address nutrition problems in the USA.

Technological solutions to nutrition and food security

The recent Global Nutrition Report finds that "malnutrition is responsible for more ill health than any other cause."[3] The report notes that the diversification of farming systems to include a greater variety of crops that offer a wider range and density of nutrients is key for addressing malnutrition and making healthier diets more readily accessible and affordable. Optimizing post-

Emerging technologies that are powering data-driven nutrition

Machine-learning algorithms

Computer software programs that can automatically find patterns in volumes of data so large that it is difficult for humans to compute them. Machine-learning algorithms power many of the digital applications that we use online every day. They are used to rank websites in search engines, make recommendations and predict outcomes.

Computer vision and image recognition

Advanced computer programs that can 'read' images and use that visual data to identify the object or image that is being 'seen.'

Farmwave is an AI-powered app that helps farmers to identify plant pathogens and pests, and to produce field reports

Harvesting peppers and preparing them for packing and processing at Santa Cruz Farm in Española, NM, USA

Wholesome Wave program activation at a farmers' market in Miami, FL, USA

harvest processing and distribution networks to reduce food waste is also an important factor in improving nutrition because, as researchers note, "postharvest losses are also nutrient losses."[4] According to the FAO, fruits and vegetables account for the largest percentage of food loss stemming from inefficiencies in the food supply chain.[5] These inefficiencies include preharvest problems, such as pest infestations, and postharvest processing and transportation conditions that impact the quality of perishable foods that must be stored at specific temperatures in order to maintain freshness.

"Technological innovation can play an important role in helping to optimize agriculture, food and nutrition infrastructures"

Technological innovation can play an important role in helping to optimize agriculture, food and nutrition infrastructures in order to support abundant harvests, improve logistics and distribution networks, reduce food and nutrient loss, and enable greater global food security now and into the future. For example, Farmwave is an AI-powered platform that was designed to help farmers identify plant pathogens, bugs and weeds by simply tapping an app. "A process that normally takes a couple of days or even weeks to get an answer from a pathologist or entomologist, we've narrowed down to about 10 seconds," says Craig Ganssle, Farmwave's founder and CEO. Trained on high-quality agricultural datasets from land-grant universities, Farmwave's algorithm is over 95 percent accurate.[6] This precision is important in order for these tools to have an impact on farm efficiency and sustainability.

It is not only undernutrition that threatens global health; overnutrition is also a primary concern, especially in developed countries. In fact, obesity is the number one cause of prevent-

able death in the USA, where nearly 40 percent of the population suffers from the condition, according to the Centers for Disease Control and Prevention (CDC).[7] One contributing factor to the obesity epidemic in the USA is the high cost and inconsistent availability of healthy, nutritious foods. More than 15 million American households – about 12 percent of the national population – are food-insecure. The United States Department of Agriculture (USDA) defines food insecurity as "households [that] were uncertain of having, or unable to acquire, enough food to meet the needs of all their members because they had insufficient money or other resources for food."[8] In a country defined by its abundance and prosperity, the so-called food-insecurity obesity paradox has come to refer to conditions in which access to nutritious food is unreliable, thereby rendering communities more vulnerable to hunger, obesity, type 2 diabetes and other associated health risks.[9] Recent digital innovations in e-commerce, online grocery shopping, and food and meal delivery services are helping to address food and nutrition insecurity by bringing fresh foods into communities that have a dearth of brick-and-mortar grocery stores or else experience other food access issues.[10]

Enabling and expanding social safety nets through technology

Government-supported healthy-eating incentive programs are among the most impactful technology-based, national programs to increase consumption of nutrient-dense foods, such as fresh fruits and vegetables. The USDA's Supplemental Nutrition Assistance Program (SNAP) is helping to close the food gap by providing financial assistance for families living below the poverty line so that they can purchase fruits, vegetables, breads, cereals, meats and dairy products.[11] Within SNAP, the Food Insecurity Nutrition Incentive (FINI) program goes a step further by using SNAP data to provide incentives for healthy purchases.[12] Specifically, the FINI program incentivizes the purchase of fruits and vegetables by doubling the amount of SNAP benefits, based on the value of the eligible fruits and vegetables that are bought.

> "Impoverished communities have not had the same level of access to online options as affluent communities"

Online SNAP redemption is an additional technology-based innovation currently being piloted. The online SNAP redemption pilot program enables program participants to use e-commerce tools to shop for groceries online. While online grocery shopping is not new for most, impoverished communities have not had the same level of access to online options as affluent communities. The online SNAP redemption pilot program is, for some participants, the first time they have ever ordered products online, especially food products. Many low-income individuals are unbanked or underbanked and, therefore, use cash for all purchases, which prohibits online ordering.[13] SNAP users are given a debit card that gives them access to the funds that the government program provides for food purchases. Having the ability to order online with the SNAP debit card helps SNAP participants enter the digital economy in a way they have not been able to before.

Not only does the online SNAP redemption pilot program have the potential to improve access to foods; some researchers suggest this shift may improve access to nutritious foods for food-insecure communities, where packaged foods in gas stations make up a disproportionate amount of the food consistently available within the community.[14] While a brick-and-mortar grocery store may not be a sustainable solution in rural communities in the USA, grocery stores that take advantage of digital technologies for shopping and delivery services can increase access to nutritious foods in rural, food-insecure communities.

> "Grocery stores that take advantage of digital technologies can increase access to nutritious foods in rural, food-insecure communities"

The benefits of digital innovation in the food industry influence not only those needing access to food, but also grocery stores implementing these innovations. The effect on the stores is currently being studied. In Opelika, AL, a rural, southern town of about 30,000 residents, Auburn University's Hunger Solutions Institute teamed up with independent grocer Jimmy Wright of Wright's Market to solve food-insecurity issues through a unique mobile market called Fresh Mobile. Fresh Mobile serves the Opelika-Auburn area and its surrounding rural areas of Lee County, an area that covers about 600 square miles. Fresh Mobile is testing the effectiveness of combining FINI, online SNAP redemption and centralized delivery as mechanisms through which to increase access to nutritious foods in rural areas while maintaining a sustainable business model.

Leveraging data to improve nutrition

In 2007, 7 years before the establishment of the FINI program, which formally incorporated healthy food purchases into the USDA's food assistance program, Michel Nischan founded

Wholesome Wave as a nonprofit organization dedicated to addressing food insecurity. Wholesome Wave was created to expand access to fresh produce in communities that would not otherwise have access. In communities across the country, Wholesome Wave began doubling SNAP benefits spent on fruits and vegetables at farmers' markets and grocery stores. At the Saturday market in City Heights, San Diego, CA, for example, Somali refugees are growing native pumpkin leaves and lablab beans and selling them to their community for deep discounts through the program.

Based on the program's success, Wholesome Wave launched a card-based reward system to support its Fruit and Vegetable Prescription Program.[15] The rewards card is powered by NutriSavings, a platform that has been described as "the first measurable nutrition benefit solution that is designed to change shopping behavior."[16] NutriSavings' scoring algorithm draws upon nutrition research that shows that diets high in fiber, protein, vitamins and minerals and low in fats and sugars lead to optimal health outcomes.[17] The algorithm produces ratings for each shopping trip based on the items purchased, and uses that information to make purchase recommendations and provide coupons to support and enable healthy food purchases.

By partnering with grocery store loyalty card programs to synchronize their point-of-sale systems with rewards for buying fresh produce, Wholesome Wave's program is improving health outcomes for individuals and their communities. Sixty-eight percent of participants in the program stay with the program through to its conclusion – about 6 months on average. And 40 percent of families reported that they will continue to eat more fruits and vegetables even after the program ends. Healthy eating incentives also grow the demand for produce from regional farmers and increase profit margins for farmers' markets and grocery stores. The program is one example of how technological applications can support multifaceted programs that target both individual behavior change and market conditions by helping to increase demand for unprocessed, nutrient-dense foods.

> "Healthy eating incentives also grow the demand for produce from regional farmers"

The future of data-driven nutrition

From facilitating individual behavior changes to addressing inefficiencies across the national and global food supply chains, machine-learning algorithms and computer vision programs are among the emerging technologies being mobilized to grow more food more efficiently and empower consumers to make the best decisions about their individual health. These tools are helping to drive innovations in food distribution and food delivery that offer the potential to address food insecurity by bringing fresher food at lower cost to more people.

The Refresh Working Group's nearly 40 farmers, small business owners, researchers, corporate partners, nonprofit leaders, educators, nutritionists, decision-makers and advocates are committed to identifying sustainable and equitable ways of leveraging data-driven technologies to improve the US food system. We recently hosted a series of public conversations to explore this topic in depth, including a livestream discussion with the former US Secretary of Agriculture, Tom Vilsack, (available on the Refresh website) and a series of panels on the impact of AI on food production, distribution and consumption at the annual South by Southwest Conference. By convening conversations that break down silos through bringing different stakeholders together and evaluating policies that support social and technological innovations as a collective, the Refresh Working Group is helping to advance a data-driven future in which healthier food is produced, distributed, accessed, afforded and consumed by everyone, everywhere.

Our work is just getting started. To learn more, please read the Refresh: Food + Tech, from Soil to Supper report, and visit the website (refreshfoodandtech.com).

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Using Ethnographic Data for Tailoring Social and Behavioral Nutrition Interventions

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when implementing them across diverse cultural settings. It will then explain how cultural domain analysis can be used by practitioners and researchers alike, to generate ethnographic data for culturally appropriate intervention design and implementation.

Key messages

- Nutrition-specific interventions now largely involve specialized nutritious foods that benefit from social and behavioral considerations for improved acceptance and utilization.
- Cultural domain data can be generated by using ethnographic methods, such as free lists and pile sorts, to gain context-specific social and behavioral insights for tailored intervention design and implementation.
- A cultural group's guiding medical belief system, food classification systems, local food and illness terms, food symbolism and nutrition-related risk perception are areas where ethnographic data can provide useful behavioral insights.
- The sociocultural aspects of global malnutrition are important to consider, but not in lieu of investments needed to address the underlying and basic factors that disproportionately contribute to suboptimal nutrition situations.

The challenge of using nutrition-specific solutions

In medicine and public health today, bioinformatics, artificial intelligence and big datasets come to mind. In reality, though, data do not need to be so 'big' or cutting edge to be useful for public health nutrition. To understand why this may be the case, this article will first discuss approaches used in public health nutrition and highlight important social and behavioral considerations

> "In reality, data do not need to be so 'big' to be useful for public health nutrition"

Let us first consider the rising popularity of specialized nutritious foods, such as Plumpy'Nut®, which are popular nutrition-specific interventions aimed at addressing inadequate dietary intake – one of the immediate causes of malnutrition.

Such foods are technological innovations, formulated by teams of food scientists, physicians and academics from high-income countries for introduction into low- and middle-income settings where malnutrition challenges persist disproportionally. Their popularity as a solution for addressing population-level malnutrition has been increasing to the point where, nowadays, entire product lines exist with nutrient formulations that address several different forms of malnutrition among people in nearly any life stage.[1] Globally, micronutrient powder is used to address iron deficiency among young children;[2] lipid-based nutrient supplements are provided for both the prevention and treatment of chronic and acute malnutrition, respectively;[3,4] and multiple micronutrient supplements are gaining support for their potential to improve the nutritional status of pregnant women and related birth outcomes.[5]

On the one hand, these nutrition-specific solutions address important nutrient gaps that are difficult to fill using local diets alone – and in the case of ready-to-use therapeutic foods such as Plumpy'Nut®, they have been truly life-saving innovations for public health nutrition. On the other hand, these product-focused

A ready-to-use therapeutic food (RUTF) being given to a child in Nigeria using the Community-based Management of Acute Malnutrition Model (CMAM)

solutions face implementation-related challenges that stifle expected health and nutrition outcomes.[6] Specialized nutritious foods typically come in the form of powders, pills and spreads – modalities that are familiar to populations in high-income settings but which are novel to most communities in development work. Indeed, the complexity of these challenges only increases when attempts are made to address malnutrition by relying on biomedical solutions across diverse contexts.

Social and behavioral nutrition considerations

Intervention lessons across settings underscore the importance of **adequate acceptance** and **appropriate utilization** of specialized nutritious foods for nutrition impact.[7–10] To nutritional anthropologists, whose biocultural perspective on food and nutrition considers the many interrelated biological and social factors that define a nutrition situation, such importance is hardly surprising. From that perspective, specialized nutritious food **acceptance** and **utilization** represent just the tip of the intervention effectiveness iceberg. Facilitating nutrition-related behavior change, with or without specialized nutritious foods, is intrinsically challenging, as the underlying behavioral determinants are complex and uniquely variable across settings. Several important, yet often overlooked, behavioral considerations are discussed below.

> "Facilitating nutrition-related behavior change, with or without specialized nutritious foods, is intrinsically challenging"

Firstly, medical belief systems, which serve as the foundation for health-related cognition, emotion and motivation, are complex. While some populations ascribe illness to externalizing factors (believing, for example, that kwashiorkor or edematous malnutrition is caused by evil spirits), others point to internalizing factors, including humoral imbalance within the body (for instance, the disproportionate consumption of hot or cold food during pregnancy).[11] In reality, every dichotomy is false, and medical belief systems do not have such clear delineation.[12] Even among biomedically oriented individuals who subscribe to clinical medicine approaches to treat illness, it is not uncommon to place trust in antibiotics to treat pneumonia (*acknowledging an internalizing factor, the pathogen*), but also to pray to a God for quick recovery (*acknowledging an externalizing factor, the supernatural beings*).

> "The nutritional illnesses that are most important to donors and practitioners may not be considered similarly serious by communities"

Participants in a workshop in Mozambique examine Nutributter®

TABLE 1: Salient illnesses identified during free listing among caregivers in Kiribati[20]

Rank	Items (Kiribati)	Item (English)	Salience		
			All	Rural	Urban
1	Kabuebue	Fever	0.781	0.793	0.761
2	Bekanako, maraki beka	Diarrhea	0.628	0.595	0.670
3	Bekobeko	Cough	0.488	0.492	0.505
4	Mumuta	Vomiting	0.324	0.364	0.291
5	Ngako	Runny nose	0.146	0.082	0.200
6	Marakinnatu	Stomach ache	0.120	0.097	0.130
7	Kaikeike	Asthma	0.111	0.062	0.170
8	Kinakanaka, kinaki	Sores	0.098	0.099	0.094
9	Wiiboi	Bad breath	0.076	0.113	0.024
10	Bwakabua, nati baraaki	Sore throat	0.065	0.041	0.093
19	Bakitaia	Malnutrition	0.033	0.027	0.029
45	Matakii	Night blindness	0.007	0.000	0.015
51	Akea n rara	Low blood (anemia)	0.005	0.010	0.000

Secondly, public health nutrition practitioners typically have their own agendas, aiming to address what they consider to be the most burdensome nutrition issues in a given context. However, the nutritional illnesses that are most important to donors and practitioners may not be considered similarly serious by communities. Formative research to inform interventions with specialized nutritious foods has consistently demonstrated that nutrition-related illnesses are far less salient and less severe than other childhood illnesses including malaria, acute respiratory illness and diarrhea.[13,14] In particular, we have found that community risk perception toward stunting, a population-level indicator of chronic undernutrition, is notoriously at odds with the high importance placed on it by the global nutrition community. There is even no local language term for stunting in many contexts and thus no associated risk perception.

Thirdly, different cultures perceive the same foods very differently, based on various factors. For one, foods have meanings associated with them based on what they symbolize, and specialized nutritious foods are particularly vulnerable to negative connotations. In Georgia, food assistance in the form of macaroni was deemed the 'food of sorrow' by refugees because of its negative association with reliance on humanitarian aid.[15] In Malawi, adult caregivers who were using a ready-to-use therapeutic food (RUTF) called Chiponde were stigmatized because of its association with child malnutrition.[13] Similarly, food classification systems differ greatly across contexts: nutritionists typically think about foods and food groupings based on their nutrient compositions (e.g., animal-source foods). However, in most communities where interventions are implemented, culturally bound dietary rules and local food availability denote the food classification systems. Specialized foods often do not fit clearly into local food classification systems – as we found in northern Mozambique, where Nutributter®, a small-quantity lipid-based nutrient supplement to be used in stunting prevention, was classified in a food category of its own, perceived differently from all other local foods and labeled "unknown".[16]

Cultural domain analysis for ethnographic data generation

Using ethnographic data from cultural domain analysis can help practitioners to better design and implement nutrition interventions that align with local cultures and improve the likelihood of success. While social norms and culturally bound food rules (e.g., food classification systems and food proscriptions or taboos) are not easily modifiable, interventions can be enhanced by using relatively simple methods drawn from cognitive anthropology, which studies the relationship between human society and individual cognition, to tailor behavioral interventions for each context.[17]

Free listing

Free listing is a method that can help reveal a community's risk perception toward nutritional illnesses.[18,19] In Kiribati, a Pacific Island country, nutrition-related illnesses were much less salient than others, ranked 19th, 45th and 51st for malnutrition, night blindness and anemia, respectively[20] (**Tables 1–2**).

Importantly, neither overweight nor obesity was mentioned during free listing, despite 80% and 50% prevalence among Kiribati women, respectively.[21,22] Low risk perception toward

nutrition-related illnesses has important implications for preventative health behaviors, yet is not unique: we have found similarly low risk perception toward malnutrition using free lists across diverse cultural settings, and believe it to be an important yet underappreciated determinant of optimal dietary practices globally.[13,14,16]

Changing the behavior of a population where the target illness is not perceived to be a threat, such as is often the case with stunting and micronutrient deficiency (i.e., 'hidden hunger'), remains a foremost public health nutrition challenge. Free listing can shed light on this important behavioral determinant for better intervention design.

Free listing also identifies local, or what anthropologists refer to as emic, words and phrases that are unique to a particular lexicon.[23] Social and behavior change communication (SBCC) often uses only clinically derived terms (e.g., nutrients) and phrases (e.g., vitamins and minerals) that reflect biomedical perspectives and have little or no meaning to local communities. Ensuring technical accuracy in SBCC messaging does not have to exclude communicating with understandable words, phrases and pictorials that resonate with vulnerable populations in which formal education and health literacy are often very limited.

Pile sorting

Pile sorting is another method that can generate data to improve interventions.[19] Items specific to a cultural domain, such as those of 'young child foods', can be sorted by community members and then analyzed using multidimensional scaling, an analytic approach that statistically produces visual representations of items based on their perceived similarities and differences. Multidimensional scaling of food items will reveal clusters of those foods based on their underlying characteristics – a representation of local food groupings, which we know usually vary by cultural context.[16,24] Most people conceptualize foods differently than trained nutritionists, who tend to think in terms of nutrients (e.g., proteins, carbohydrates and vitamins).

> "Most people conceptualize foods differently than trained nutritionists"

Local food classification systems derive from what is locally available and culturally prescribed, not from the underlying nutrient values of food. Pile sorting in Mozambique revealed that young child foods are thought of as *common foods, special foods* and *early meal foods*, which include categories quite different from those nutritionists conceptualize[16] (**Figure 1**).

Notably, when Nutributter®, a specialized nutritious food, was introduced into the Mozambique pile sort, data revealed that participants did not perceive it similarly to local foods or food groups.

FIGURE 1: Multidimensional scaling map of Macua cultural group (northern Mozambique) food classification, including Nutributter®, a specialized nutritious food for the prevention of chronic malnutrition[16]

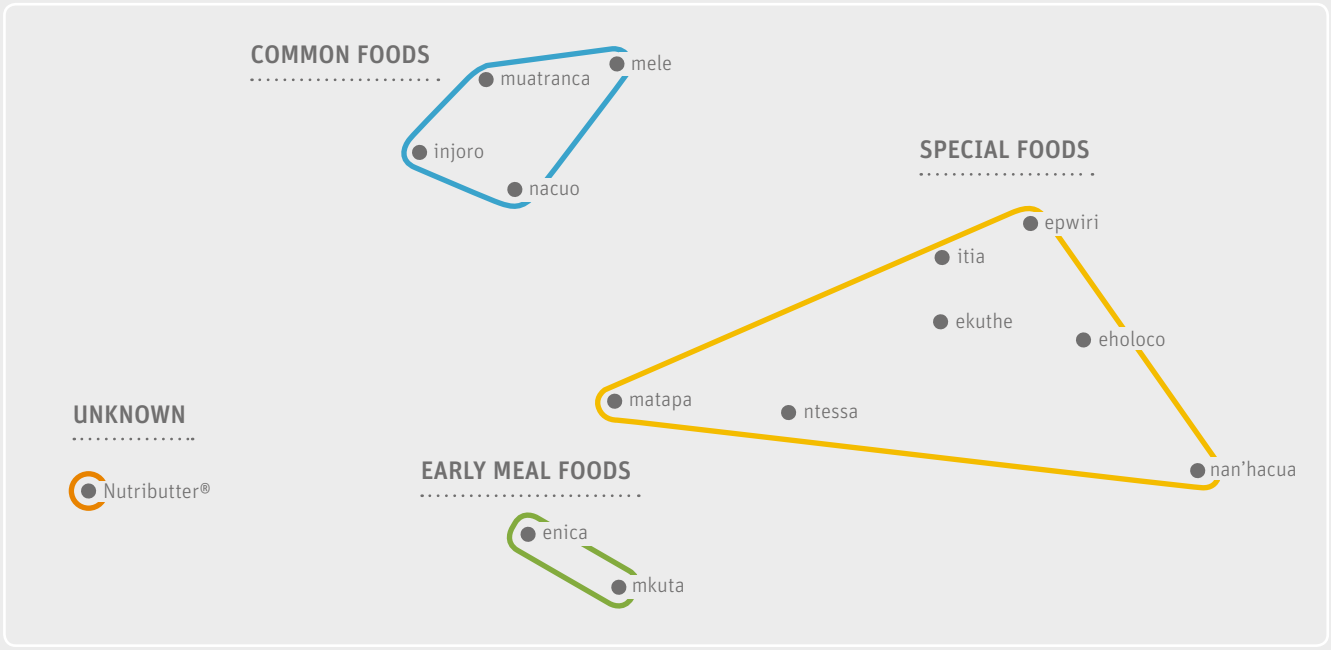
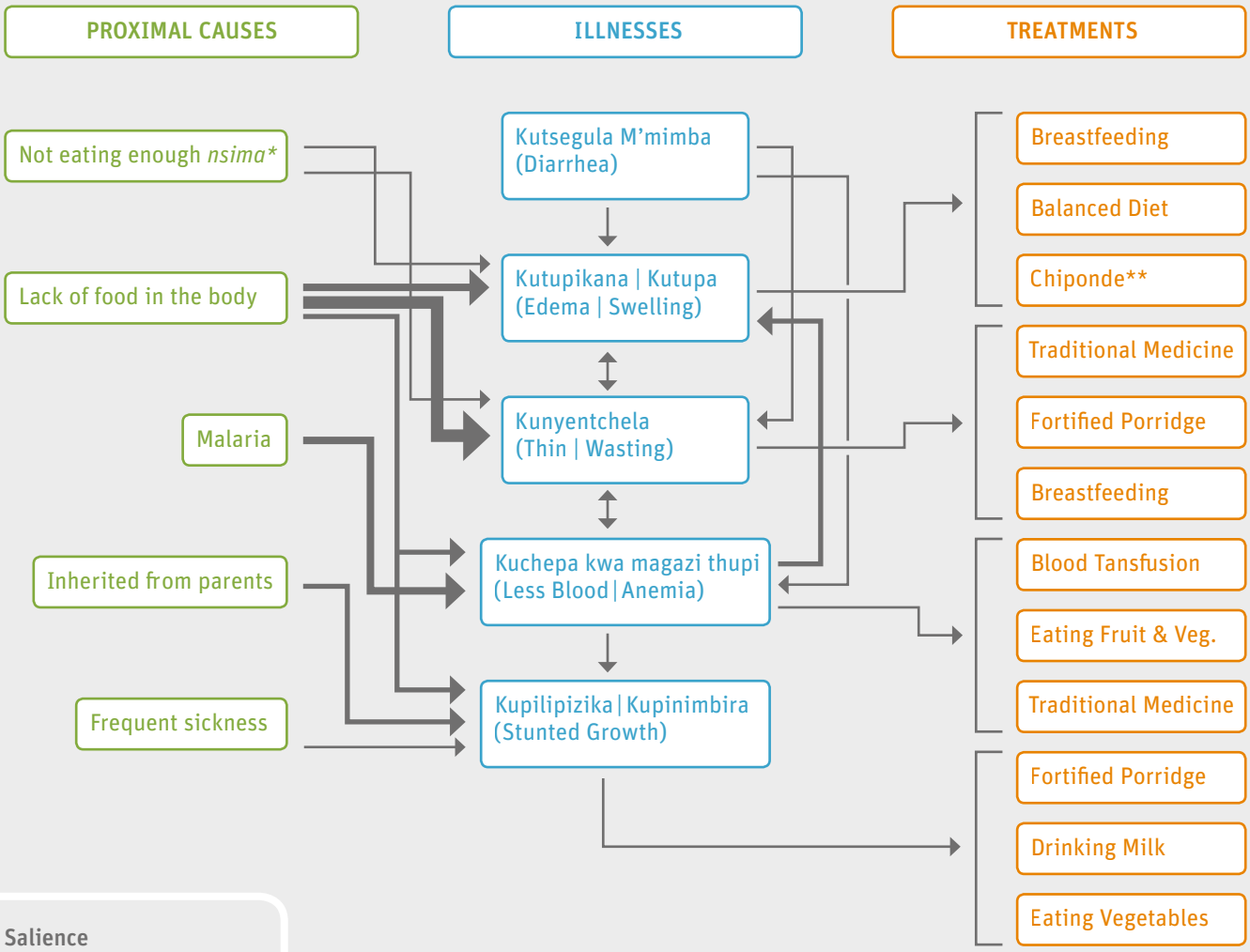


TABLE 2: Descriptions and examples of useful ethnographic data collection methods

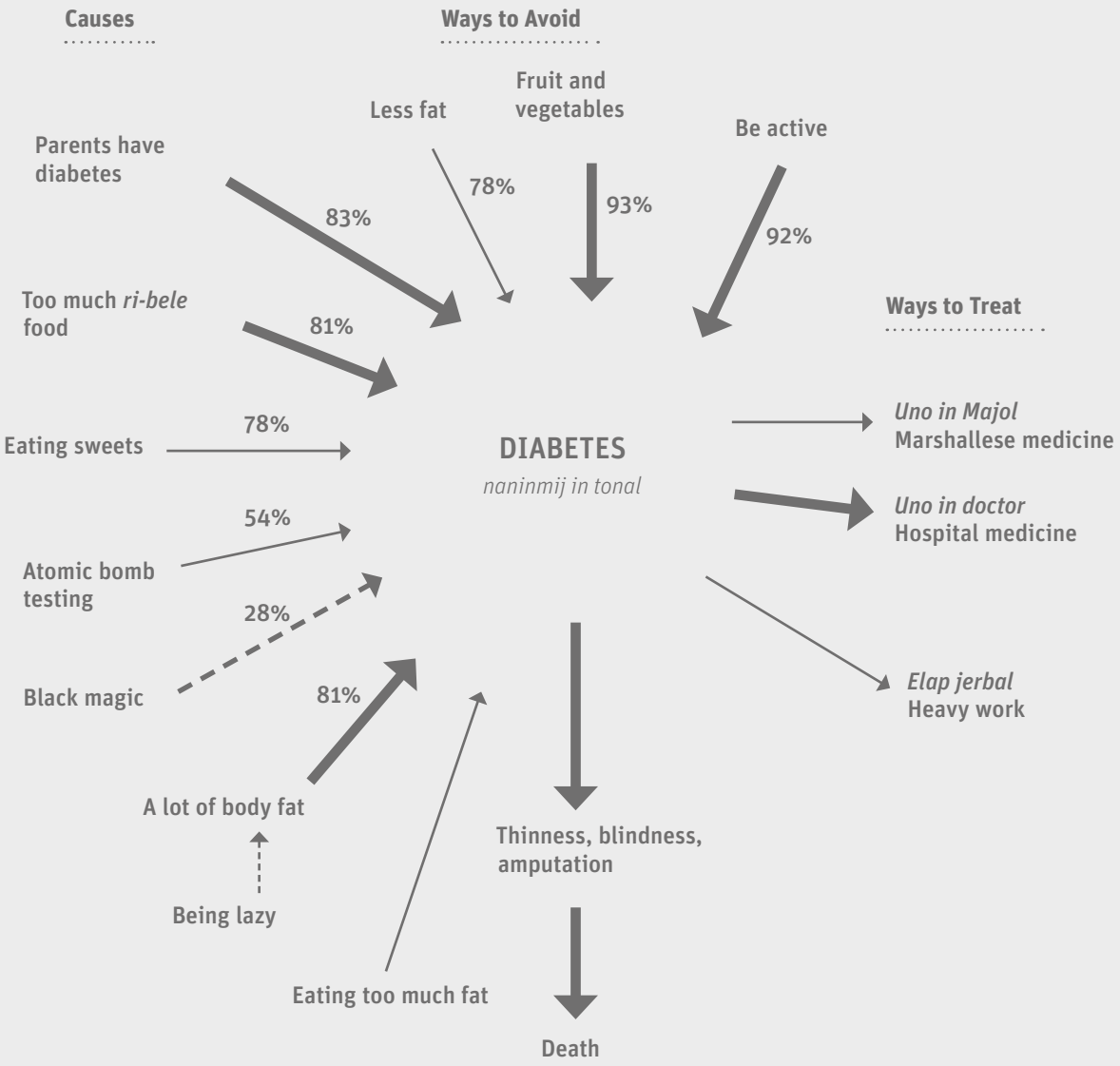
Method name	Brief description	Example of question prompt	Output
Free listing	Listing activity whereby a participant is asked to list as many items as possible within a cultural domain.	"Please list as many illnesses as you can."	A rank order of listed items, such as illnesses, reflecting their relative salience to a culture.
Pile sorting	Sorting activity that asks a participant to classify or sort familiar items into groups based on how similar or different they are.	"Please put these illness terms into piles based on how similar or different they are."	Clusters of items that reflect local classification systems (e.g., 'illnesses caused by evil spirits' versus 'illnesses caused by food').

FIGURE 2: Ethnomedical model of nutrition-related illness in Ntchisi, Malawi[13]



Nsima is cooked maize flour
**Chiponde is a locally produced specialized nutritious food for the treatment of acute malnutrition in Ntchisi

FIGURE 3: Ethnomedical model of diabetes in the Republic of the Marshall Islands[27]



Source: Cortes LK, Gittelsohn J, Alfred J, Palafox NA. Health Education & Behavior, Vol. 28, Issue 6. Formative Research to Inform Intervention Development for Diabetes Prevention in the Republic of the Marshall Islands. pp. 710, copyright © 2001 by SAGE Publications, Inc. Reprinted by permission of SAGE Publications, Inc.

Promoting nutritious local foods, as well as specialized nutritious foods where these are introduced, is often a core aspect of SBCC, yet without such data describing local classification systems it is not possible to tailor health messaging for behavior change.[25] Nutritious food promotion that does not align with local classification systems may cause confusion or disregard among communities. Further, misaligned messages may hurt the credibility of implementers, who are usually 'cultural outsiders' to the communities that they are trying to serve. Pile sorting can generate useful data to tailor SBCC for improved nutrition communication that resonates with local communities.

Ethnomedical models of nutritional illness

Free list and pile sort data, when combined with in-depth interview and direct observation data, can form ethnomedical models. An ethnomedical model of illness is a visual representation of the collective factors locally defining a disease and based on the community perspectives. Often, an ethnomedical model will differ greatly from a purely biomedical model, which focuses primarily on the biological causes of disease.

Ethnomedical models can thus be very informative tools that not only depict local medical belief systems around health and nutrition, but also inform intervention design by highlighting important entry points reflective of sociocultural dynamics[13,26,27] (**Figures 2–3**).

A mother and child with Nutributter®, Mozambique

RUTF for severe acute malnutrition, Nigeria

Visual presentation of cultural domain data in an ethnomedical model is often appealing and digestible, and thus a useful advocacy tool for communication with policymakers and management, who often do not appreciate the importance of cultural context in effectively addressing malnutrition.[12]

"The cultural contexts in which specialized nutritious foods are proposed as solutions need to be understood before intervening"

Conclusions

The cultural contexts in which specialized nutritious foods are proposed as solutions need to be understood before intervening. The factors contributing to food acceptability and utilization are much more complex than perceptions of packaging or organoleptic characteristics (e.g., taste, odor, color and other characteristics associated with sensory perception), which tend to be the primary focus of most formative work.[28] Dietary traditions are by nature longstanding, and perceptions of foods and community-level norms manifest uniquely in each setting. While ethnographic information is not a panacea for public health nutrition challenges, which require systems-level investments for sustainable change, it is a prerequisite for culturally appropriate programming, especially where interventions necessitate behavior change.

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Fill the Nutrient Gap Assessment

Using multisectoral data to prevent malnutrition

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Key messages

- The Fill the Nutrient Gap (FNG) assessment brings together information from multiple sectors to inform the prevention of malnutrition.
- Integral to the assessment are food price information and data on the economics of households, such as income and expenditure.
- A food systems approach is used to contextualize information on dietary intake considering production, processing, transport, marketing and consumption.
- Lack of data and uncertain quality are important challenges in the assessment.
- The assessment also highlights the informative value-add that nutrition data has for other fields, such as agriculture, education, the private sector or the supply chain, which can help to identify opportunities for making them more nutrition-sensitive.

Aim of the FNG

The Fill the Nutrient Gap (FNG) assessment is an innovative methodology that brings together information from multiple sectors to inform evidence-based interventions and policy changes to prevent malnutrition.[1] It takes a life-cycle approach in estimating barriers to having a nutrient intake that is in line with recommendations on an individual level and identifying solutions for improvement. Across the process, the analysis makes use of quantitative as well as qualitative data with information coming from many sectors and sources, including grey literature, formative research and peer-reviewed articles, as well as local and national studies and surveys.

> "The Fill the Nutrient Gap assessment is an innovative methodology that brings together information from multiple sectors"

This more traditional approach to a situation analysis – i.e., using literature review and analysis of cross-sectional survey data – is enhanced by the integrated Cost of the Diet analysis. This analysis, which uses data on food prices and food expenditure, estimates the cost of a nutritious diet and the affordability of this expenditure for a household,[2] provides an indication of likely nutrient gaps, and is also used to model the potential impact of different interventions that improve the nutrient content or affordability of nutritious foods.[3,4] The other characteristic that sets the FNG apart from other situation analyses is the multisectoral approach across all phases, with stakeholders from different sectors identifying the scope of the analysis, contributing relevant information and data, and formulating priorities for policies and programming based on the analysis. The cross-sectoral, evidence-based systems approach of the FNG towards addressing malnutrition is highly appreciated by countries' stakeholders.

> "Data for the Fill the Nutrient Gap assessment comes from a wide range of sources"

© Saskia de Pee, WFP

Stakeholders suggest secondary data sources for Fill the Nutrient Gap assessment, Dhaka, Bangladesh, April 2019

What data are used?

As mentioned above, data for the FNG assessment comes from a wide range of sources and covers multiple sectors. For the Cost of the Diet part, the two main data needs of food price and household expenditure information can be met by several sources. For the 25 FNG assessments that have been carried out or are currently ongoing, the majority (15) have made use of existing food price data, and all have used existing expenditure data.

For food prices, the most frequently used data sources are surveys of, or designed in reference to, the Living Standards Measurement Study (LSMS) by the World Bank. For several other countries (Ghana, Lesotho, Tajikistan, Sri Lanka and Myanmar), food prices from Consumer Price Index (CPI) data collection were used. Only the FNG in the Philippines made use of food price data that had been collected by a designated nutrition survey (the National Nutrition Survey by the Food and Nutrition Research Institute in the Philippines). Food price data is therefore one example of data from outside nutrition that becomes very relevant when conceptualizing nutrition from a food environment perspective. The food environment refers to the physical, economic, political and sociocultural context in which consumers engage with the food system to make their decisions about acquiring, preparing and consuming food.[5]

Similarly, for expenditure on food, data from outside the nutrition and health sector are used to estimate the proportion of households that are unable to purchase a nutritious diet (non-affordability), such as the LSMS, panel surveys or income and expenditure surveys specific to the country. In most cases, the FNG uses per capita estimates adjusted for inflation and household size differences. Additional time adjustments, using CPI data, may be made if data sources do not date from the same point in time.

> "Multisectoral information is used to contextualize the findings and inform the discussion on possible interventions"

How are the different data points brought together?

Once cost and non-affordability are estimated, the second level of inquiry begins, which utilizes multisectoral information to contextualize the findings and inform the discussion on possible interventions. In this analytical step, secondary data and Cost of the Diet results are combined to forge a multisectoral lens on nutrition.

Market data, such as the price fluctuation of staple foods over time, and retail or supply chain information, can be used to estimate both the commercial feasibility of interventions as well as their potential nutrition impact. In the FNG analysis in Uganda, estimates of postharvest losses across the value chain[6,7] were used to estimate different levels of improved earnings for small-


© Natalie West, WFP

Food price data collection at Medine Market, Bamako, Mali, April 2019

World Food Programme and partner enumerators collecting food price data during a pilot market survey in Bujumbura, Burundi, November 2018

holder farmers and to quantify the impact for household staple supply and subsequently their food security if these losses could be reduced. Information on locally produced fortified foods were used in the Philippines to test products' potential cost-effectiveness in filling the estimated nutrient gap.

Information on the nutrient composition and consumption of biofortified foods, such as the International Food Policy Research Institute (IFPRI) and HarvestPLUS research carried out in Uganda,[8] can be used to approximate the impact that consumption of improved varieties can have on the nutrient intake of individuals.

Program information, both *ex ante* and *ex post*, was used in several countries to show the impact that agriculture, education and social protection interventions could have on the affordability of nutritious foods both for individuals and for households. Consumer purchasing information from cash safety nets (as available through post-distribution monitoring surveys) can identify behavioral barriers to having a nutritious diet, which may complement the analysis on economic barriers. Production information from smallholder agricultural programs, such as Helen Keller International's home gardens,[9] is used to calculate the potential impact of these interventions on the nutrient gap, taking both a view of the increased availability of micronutrient-rich foods and an economic perspective evaluating reduced cost to the household.

Challenges and limitations

Limited availability, uncertain quality and restricted access to data are challenges to this type of analytical work. One key aspect in confirming the quality of data is to triangulate data sources, whenever possible. For example, comparing consumption information to production or import/export data can highlight discrepancies between data sources. Similarly, in the absence of consumption information, production and import data can serve as a rough proxy to estimate per capita intake.

"Limited availability, uncertain quality and restricted access to data are challenges to this type of analytical work"

In many cases, there are no extensive datasets that reliably report on both food expenditure and market prices, disaggregated to subnational administrative units. Proxies for food expenditure can be based on a ratio applied to income information (e.g., the poor often spend 60–70 percent of their income on food). In most cases, market price data is only available for a limited number of foods, precluding estimation of the cost of a nutritious diet. Information on consumption and money spent on specific food items, in particular from household income and expenditure surveys, has been a good alternative source in several countries. Where that is also not available, we have resorted to the primary collection of food prices from markets.

Another issue arises from the lack of information on household composition that is available at a population or geographic

level. As individual nutrient needs vary according to age, sex and health status, a population-level estimate cannot do full justice to the individual situation, and vice versa. While overall costs are necessarily driven by a specific set of individual costs, expenditure is often reported as a household total. Therefore, the estimated proportion of non-affordability might either fall short of, or else lie above, the actual non-affordability. With the increasing availability of more nuanced datasets that include information not only on a household's number of members but also on their sex and age, expenditure for specific individuals can be estimated more precisely, allowing for increased accuracy of estimated non-affordability.

Outlook

In recent years, the relationship between the cost and the affordability of foods and their consumption has become more recognized and understanding more nuanced. This has resulted in an increased readiness to collect food prices for a larger variety of foods, particularly fresh foods, more regularly. One example is the expansion of the food list in government or WFP-organized data collection.

From a data perspective, much has happened since 2015, when the first FNG analysis was conducted. One of the biggest opportunities has come with automated analysis, which has the potential to eradicate large portions of the manual labor associated with data processing and to provide more up-to-date, granular and frequent information. Making sure that the analytical tools are fit for purpose and accessible to a large variety of users is important and can include sharing of software code to expert users to invite them to develop additional features to meet specific analytical needs.

> "Making sure that the analytical tools are fit for purpose and accessible to a large variety of users is important"

The FNG work has also been able to demonstrate the usefulness of including nutrition data in other sectors: within WFP, working with the Supply Chain Planning Unit, nutrition information such as food composition tables, recommended nutrient intake levels, portion sizes and nutrient indicators were integrated into a supply chain planning tool (OPTIMUS). The OPTIMUS tool brings together information across the supply chain (procurement, logistics, nutrition, etc.) to optimize the distribution and implementation of interventions. This development of multisectoral engagement on data not only shows the use case of multisectoral data for nutrition, but also demonstrates how other sectors can use nutrition data to improve their programming, i.e., making programming more nutrition-sensitive.

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Portraying Your Data

A guide to creating infographics

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Key messages

- Understanding and acting on various forms of data are key to tackling a wide range of problems.
- Data can be overwhelming, and an important component of the nutrition data value chain is to communicate the insights effectively and efficiently.
- Visual storytelling can be a powerful tool to translate insights gathered in order to engage people to act on important nutrition data and also to help policymakers arrive at their decisions quickly.

From the moment we wake up to the time we go to sleep, we are bombarded with data from innumerable sources. We collect data points almost subconsciously, but on their own they don't mean anything. Data is only as useful as it is understandable.[1]

But how do humans make sense of data?

Two ways of understanding data are through stories and visuals. According to a study conducted by neuroscientists, words lit up only two parts of the brain, but when they conveyed a narrative, they activated more than two.[2] This research showed how "stories ... stimulate the brain and even change how we act in life."[3]

If humans make better decisions based on the stories they engage emotionally with, and if human brains can process visuals more rapidly than text, how might we use visual storytelling – a tool that combines both stories and visuals to engage people and make them act upon important nutrition data?

> "Evidence-based narratives are gaining precedence for driving change"

While there are many ways out there for visual storytelling, evidence-based narratives are gaining precedence for driving change and influencing laypeople and decision-makers alike. Storytelling with data includes three key elements: **data, visuals and narrative**. Unlike the presentation of mere statistics, data storytelling increases memorability, is more persuasive and can engage the viewer more.[4] The shift toward data-driven decision-making is transforming how companies organize, operate, manage talent and create value.

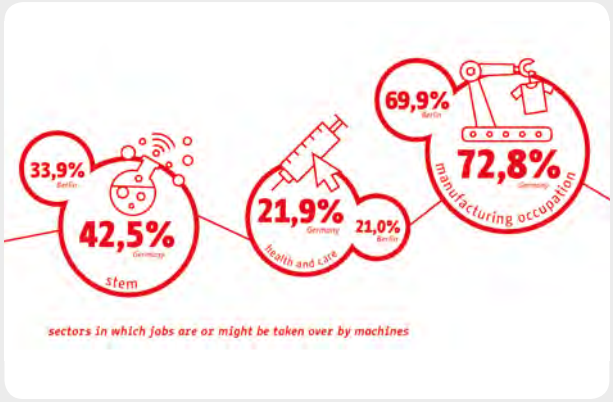
A good infographic, one of the many tools used for storytelling with data, combines a strong narrative with engaging visuals so as to present significant insights. When combined with an action-oriented title or subtitle, the infographic becomes even more memorable.[5] Infographics can therefore be a powerful tool for translating insights into actionable advice, and can be directly useful for decision-making purposes.[6]

> "The five attributes of a great infographic are contrast, hierarchy, accuracy, relevance and truth"

FIGURE 1: The Food of Art by Nadeem Haidary

The Food of Art by Nadeem Haidary analyzes masterpieces for their nutrition content; here the visual and the data together make a compelling narrative

FIGURE 2: An example of a digital poster



The information is presented effectively without the larger context in this infographic designed by Jana Eger
Credit: © Copyright SenIAS (www.berlin.de/arbeit-4-punkt-0/online-dialog/artikel.609914.php)

FIGURE 3: Caloric Consumption by Nadeem Haidary

In this infographic, the data is not just a number but a more immersive way of storytelling

What is an infographic?

An infographic or information graphic is a visual representation of information or data.[7]

The five attributes of a great infographic are contrast, hierarchy, accuracy, relevance and truth.[8] Unlike data visualizations, infographics explain data rather than just showing it. They are often confused with digital posters – their 'simpler cousins', which are an effective format of graphic communication used when a simple message has to be communicated.[9] In contrast to digital posters, however, infographics expand the essence of the data by adding context and metaphor.[10]

Infographics are ideal launchpads for an immersive style of storytelling. Infographics can be animated and made interactive for screens. They can be painted as murals, and parts of them can be made tactile for the viewer to interact and engage with. They can even be transformed into spatial installations where the audience experience the data physically. The opportunities are endless.

Getting started

Before starting to design an infographic, it's useful to address the what, the who and the how.

What is it?

Michael Bierut, partner at the design consultancy Pentagram, says: "The great thing about graphic design is that it is almost always about something else. And if I can't get excited about whatever that something else is, I really have trouble doing good work as a designer." As with any kind of design, designing an effective infographic means understanding the content clearly and being interested in the insights it conveys.

Who is the infographic for?

Clearly defining who the infographic is for determines its tone and the style, while also helping in the building of the narrative – which could be explanatory (seeking to objectively educate or inform), editorial (suggesting value judgments), persuasive (seeking to influence or sway) or exploratory (testing multiple alternative hypotheses).[11]

How is it going to be used?

Is it to be printed? If yes, at what scale? The level of detail for a billboard versus a flyer will be different. Is it to be viewed on a screen? These might be static, animated or interactive. Is it going to be used in a presentation? Presentations are usually accompanied by an explanation, and hence would not require as much detail as would be necessary in the case of a print version. Other details such as color modes (CMYK or RGB), paper sizes, paper orientation and file formats should be ascertained before moving forward.

The design process

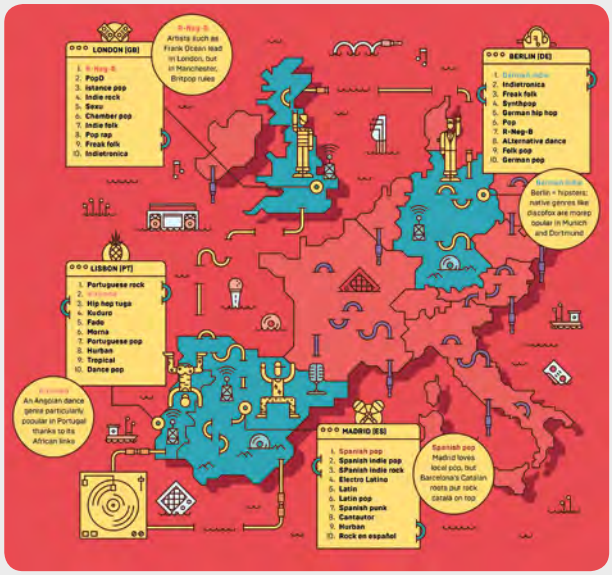
Though an iterative process, designing an infographic from start to finish can be divided into four major steps.

Step 1: Gather information

Understanding the material helps in turning the data and the insights into a convincing infographic.

This step involves combing through the entire content, reading up on everything related and finding the narrative. All the material is processed – edited and cut for using in the infographic as messaging or as cues for visuals. This is followed by a discussion with the team and/or the client.

FIGURE 4: Target audience definition



Defining whom the infographic is for helps in determining the approach to be taken
Credit: Infographic designed by relajaelcoco for The Wire Magazine

FIGURE 5: The influence of the chosen medium

As this infographic 'Data for Culture' shows, the medium influences the design
Photo: K. Szewczyk CC by 4.0 Medialab Katowice

Step 2: Develop prototype

Once the narrative is agreed upon, all the material processed for it is taken and made into a tiered structure. The central argument is supported by other portions of information. A hierarchy like this allows for the infographic to have a clear focus but also permits the viewer to move around and find correlations on their own. According to Gareth Cook, a Pulitzer Prize-winning journalist, this is a crucial part of their persuasiveness. Finding stories on their own gives the viewers confidence that you are giving them the whole story.[13]

Once the hierarchy and the information flow are determined, the wireframe (a visual representation of the infographic's structure) is developed and a rough layout is composed, using placeholders for the final text and the visuals. The developed wireframe is used as a tool for discussion with the team and/or the client to bring everyone onto the same page and uncover issues with the narrative, if any.

Step 3: Illustrate

Once the wireframe is finalized, the format for presentation is chosen and a visual approach is decided. The visual approach might depend upon the brand guidelines or on any other specifications the client might have. The format is also chosen based on the brand tone, the type of content and/or the user. Some of the most common formats are: *vectors* (a type of graphical representation using lines to construct the outlines of the objects), *illustrations, photographs, data visualizations* or a combination of all of these. After a rough draft is sketched out, the illustrations are finished digitally using software packages such as Adobe Photoshop and Adobe Illustrator.

Step 4: Iterate

The infographic is now in its penultimate form and goes through the last stages of changes. A fail-safe way of knowing if your infographic is effective is by showing it to people who haven't been a part of the creation process. A compelling infographic strikes a balance between providing sufficient context and a focused message, so that viewers can move around it without getting disoriented. For data visualizations especially, the 'squint eye test' is a good method to test if the

Color modes

The color mode or image mode determines how colors combine based on the number of channels in a color model. Different color modes result in different levels of color detail and file size.

For instance, CMYK (cyan, magenta, yellow, black) has four channels. This color mode is used for images in a full-color print. RGB (red, green, blue) by contrast has three. This mode is used for images on the web or in emails to reduce file size while maintaining color integrity.[12]

most important information jumps right through when one squints and observes it.

Is your infographic lying?

Information is curated during the process of visualizing it, but excluding certain data or transforming data from one format to another may pose a danger of distortion. There is also a danger of oversimplifying complex data. As a user or a viewer, it is important to look for any bias (unconscious or otherwise) that might exist, and to interrogate the credibility of the sources and the semantics.[15]

There is a certain credibility attached to visuals. According to John Burn-Murdoch, data journalist for the Guardian, one of the reasons this happens is because of our education system. We are encouraged to critique texts, while the visuals present the final results. People trust images. But with trust comes responsibility, and as with research investigations, the design process also needs "to focus on specific investigative questions, to conduct rigorous analyses, and to communicate the most important and actionable results to a specific audience in ways that are appropriate to their level of knowledge."[16]

Designing infographics for nutrition

One of the key messages of the 2015 Global Nutrition Report was: "Although a great deal of progress is being made in reducing malnutrition, it is still too slow and too uneven."[17] A multisectoral approach is the need of the hour if truly disruptive solutions are to be delivered. How do we collaborate with other sectors when different sectors speak different jargons? How do we develop a common language? In such situations, storytelling

Techniques for telling stories with data graphics[14]

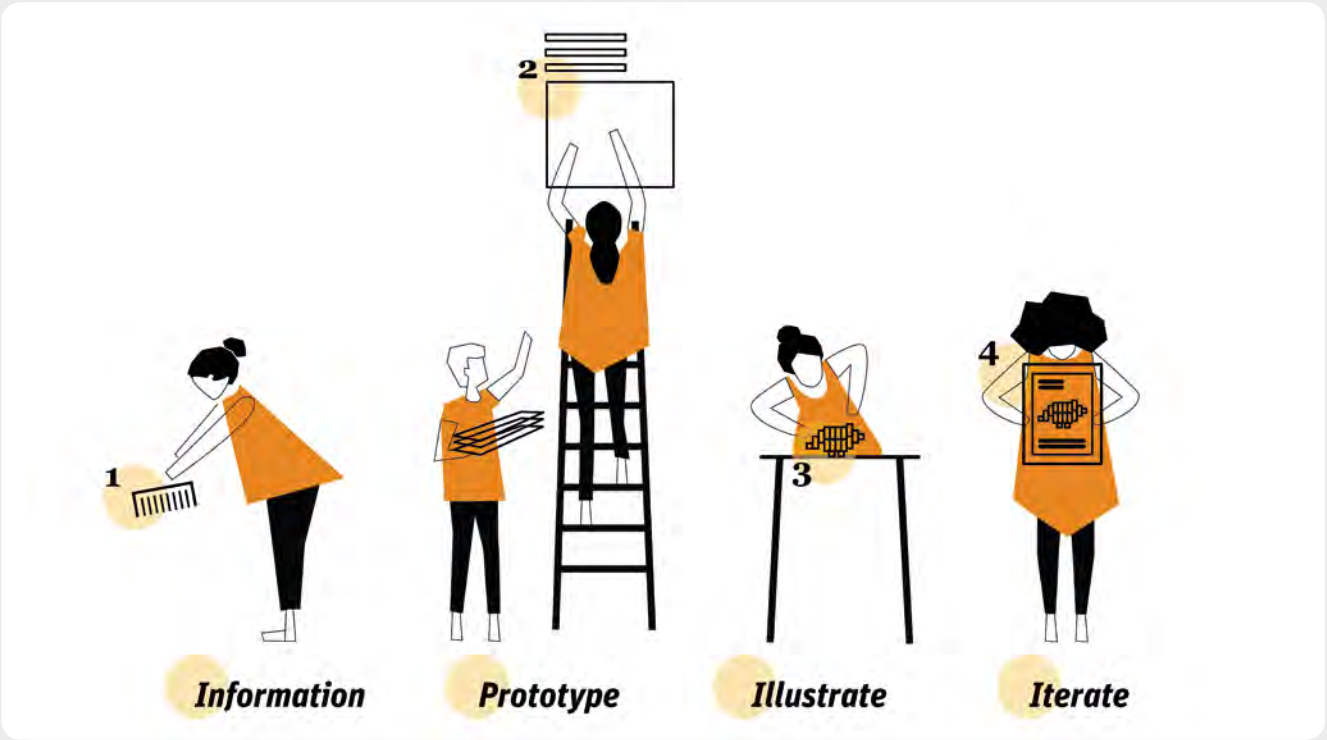
Visual narrative tactics

1. *Visual structuring* (consistent visual platform, progress bar, etc.)
2. *Highlighting* (color, size, boldness etc.)
3. *Transition guidance* (matching on content, etc.)

Non-visual tactics

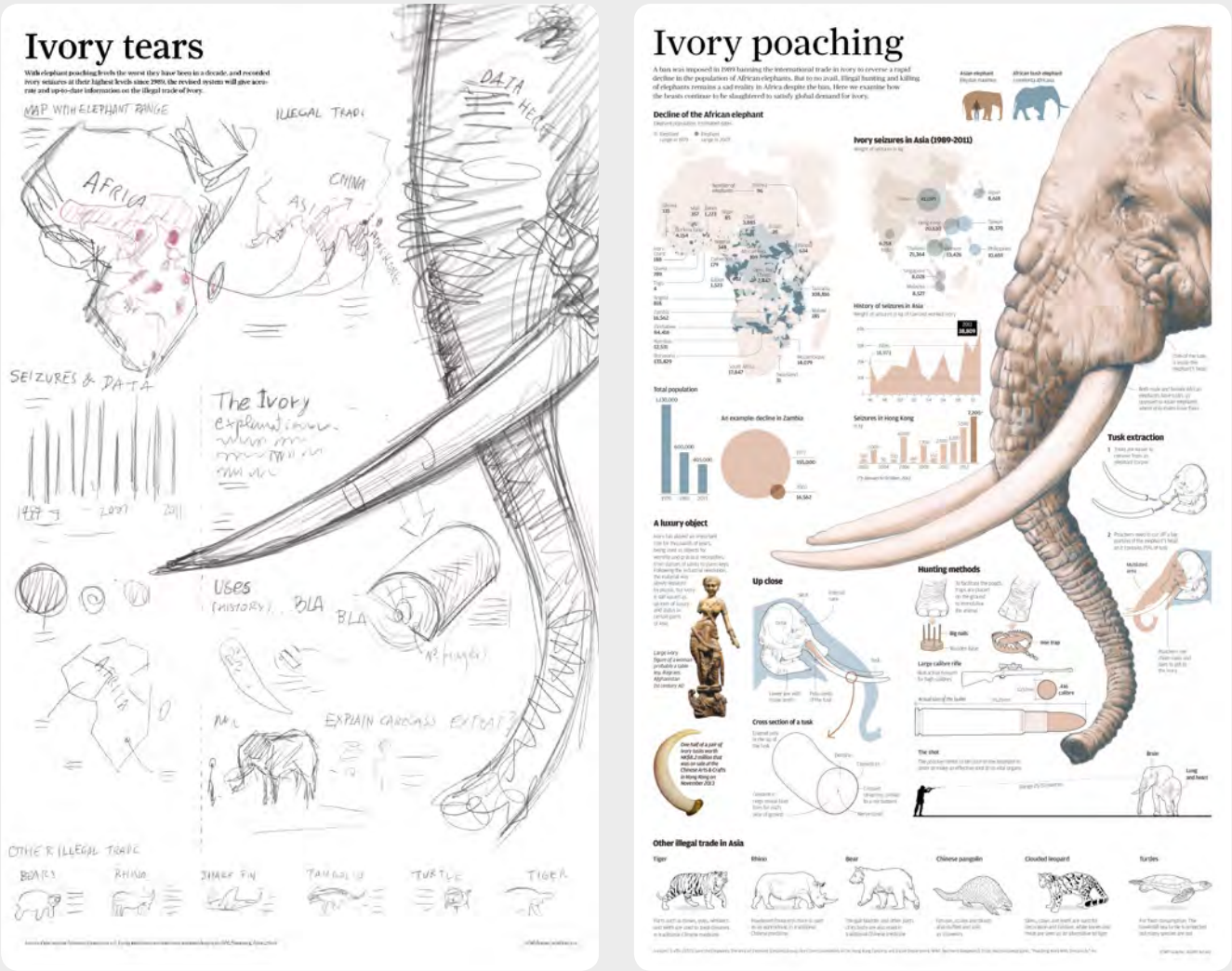
1. *Ordering* (ways of directing the path viewers take – this could be a linear path imposed by the designer, a user-directed path where the user chooses to go down one path among multiple alternatives, or no paths at all)
2. *Interactivity*
3. *Messaging*

FIGURE 6: The four steps in the making of an infographic



The making of an infographic, although not a linear process, can be divided into four major steps. **Credit:** Illustration and design by Anne Milan

FIGURE 7: An example of a finished infographic (right) and the wireframe (left)



The finished infographic uses a combination of illustrations, vectors and data visualization to give the larger context
Credit: Infographic by Adolfo Arranz for South China Morning Post

tools can prove useful. Storytelling through visuals has been an intrinsic part of human existence since the beginning of time. What are cave paintings but insights gathered from a sample set and then visualized using the simplest tools available? Visuals are powerful, and cut across the boundaries of sector-specific jargon. Perceived meanings of certain signs, symbols and colors are deeply ingrained culturally, and when deployed in an infographic can be used to our advantage in bridging the gap.

"What are cave paintings but insights gathered from a sample set and then visualized using the simplest tools available?"

Laying out complex nutrition data without communicating key insights is a missed opportunity. For example, imagine that a nutrition label contains data, but the insights are missing. How do consumers decide what is actually healthy for them? How do they choose between two products? Proposals such as 'My Dream Food Label' by New York Times journalist Mark Bittman and Werner Design Werks Inc. explore the idea of conveying key insights, in addition to the nutrition data, in order to prompt consumers to action.

To communicate key insights, researchers and data analysts need to collaborate with visual designers and information visualizers. Different actors taking part in the design process will bring together different perspectives and will enrich infographics and other storytelling tools before they reach the decision-makers.

Next time you are using data, consider adding a compelling story to it, and then process it to highlight the narrative. This will help you portray your data in the best possible light to initiate action.

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"Next time you are using data, consider adding a compelling story to it"

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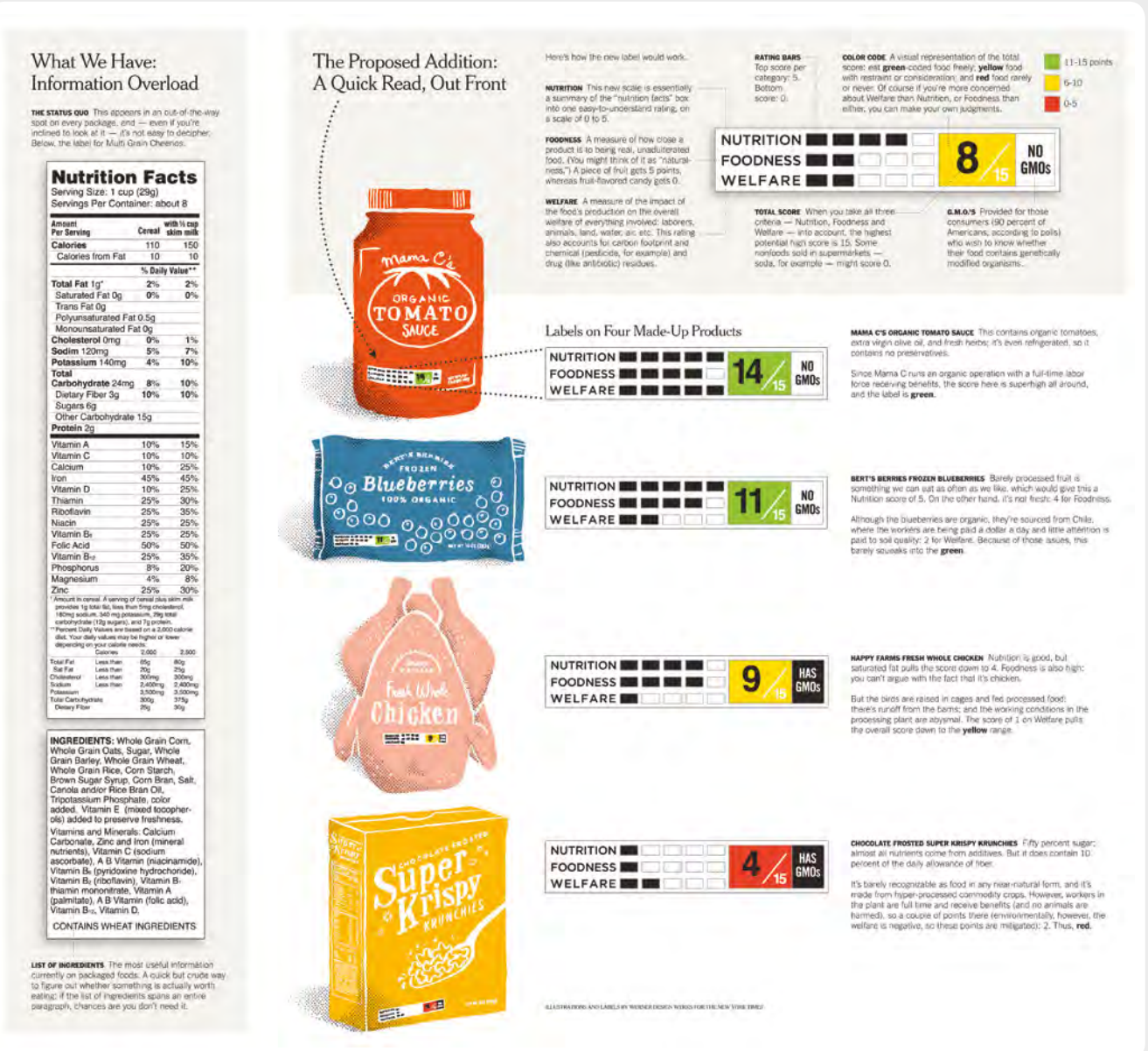
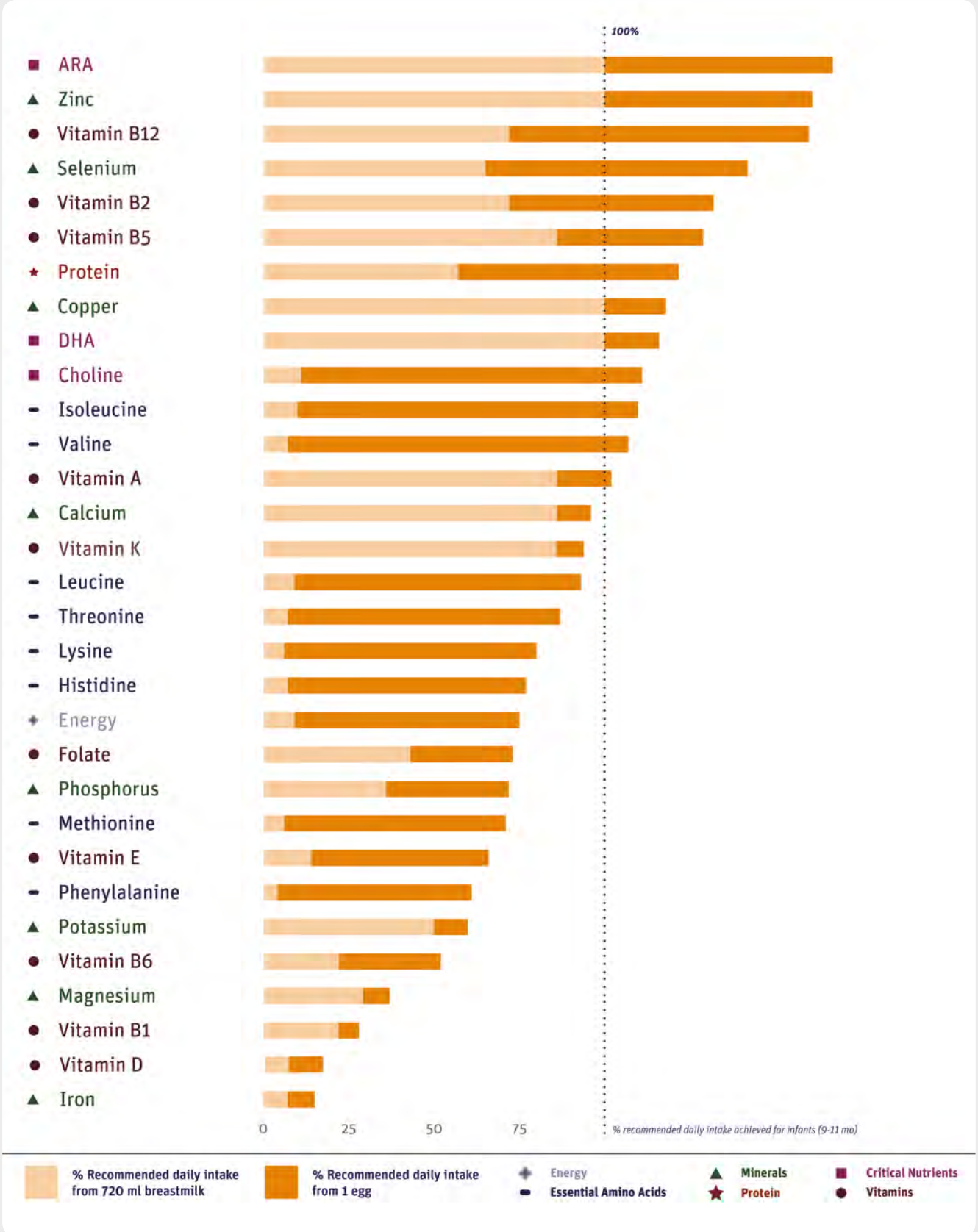
FIGURE 8: 'My Dream Food Label'



Design studio: Werner Design Werks, Inc. Content creation: Mark Bittman, Sharon Werner and Sarah Forss. Art directors: Matthew Dorfman and Erich Nagler, New York Times

FIGURE 9: Nutrients delivered by one egg to a young breastfeeding child 9–11 months old



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Global Data Visualization Tools to Empower Decision-Making in Nutrition

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This analysis was conducted by Results for Development Institute (R4D) as part of the Data for Decisions to Expand Nutrition Transformation (DataDENT) initiative, which aims to transform the availability and use of nutrition data by addressing gaps in nutrition measurement and advocating for stronger nutrition data systems. For DataDENT, R4D conducted a landscaping of 22 global data visualization tools in nutrition, as well as a literature review of data visualizations to complement the landscaping. These activities aim to improve the uptake of data for decision-making in nutrition.

Key messages

- Well-designed data visualization tools (DVTs) can solve certain data challenges facing nutrition stakeholders. DVTs help people understand the meaning of data by placing the most relevant data in easy-to-interpret visualization formats such as bar graphs or maps, and can facilitate data-driven decision-making.
- The number of DVTs in existence is growing, which may be useful if individual DVTs serve different and complementary purposes. However, there are inefficiencies in the landscape. The global nutrition community of DVT producers and funders could: support coordination to increase synergies and share learnings; convene DVT producers that report on common indicators to reduce divergent messages; and strengthen capacity to interpret and use data for decision-making.
- Three key insights for those developing DVTs are likely to increase the effectiveness of DVTs: having a clear theory of change about the key decisions (and respective users) that the DVT aims to support and what actions are needed to deliver that change; including more actionable indicators; and ensuring the DVTs' formats align with users' data literacy levels and needs.

Nutrition data users face many challenges

Thanks to the significant investments in the nutrition data landscape over the past decade, more data is available to support the work of nutrition policymakers, implementers, donors, advocates and researchers. Data is collected through routine administrative health information platforms (e.g., District Health Information System 2 [DHIS2]), large-scale household surveys (e.g., Demographic and Health Surveys [DHS], Multiple Indicator Cluster Surveys [MICS] and Standardized Monitoring and Assessment of Relief and Transitions [SMART] surveys) and project evaluation studies or monitoring platforms (e.g., Scaling Up Nutrition Monitoring, Evaluation, Accountability and Learning [SUN MEAL] and Hunger and Nutrition Commitment Index [HANCI]). Hundreds of indicators on nutrition outcomes, intervention coverage, underlying determinants and the enabling environment are collected across global data platforms.

While the increased amount of data available represents real progress, challenges still remain. Through the DataDENT engagement with nutrition stakeholders, we have identified that they are confronted with many challenges including:

- accessing data at the right geographical level (e.g., subnational level) or trend data to track progress across indicators;
- having clarity on which indicators (and corresponding definitions) are most critical for the decisions they need to make; and
- analyzing and interpreting data to inform decision-making.

FIGURE 1: Four typologies of data visualization tools: dashboards, scorecards, indices and profiles

Dashboards

Present the most critical performance indicators for a particular goal on a single screen – often used for operations or management purposes

Example: UNICEF/WHO Global Breastfeeding Interactive Dashboard

Scorecards

Compare performance across indicators to display status and monitor progress – often used for advocacy and accountability purposes

Example: African Leaders Malaria Alliance

Indices

Calculate several indicators into a single indicator (or composite score) to rank geographies or other units – often used for advocacy and accountability purposes

Example: Access to Nutrition Index

Profiles

Provide a snapshot of how a geographic region is doing in a particular sector – often used to spread awareness across broad audiences

Example: Global Nutrition Report Country Profiles

Well-designed data visualization tools (DVTs) can help address some of these challenges.

Data visualization tools: a critical tool to help decision-making in nutrition

Our brains have limited capacity to prioritize and process large quantities of data in raw form.[1] Not only do we process visuals more rapidly than text, but data is often more persuasive when presented in graphs rather than in tables.[2]

> "Data visualizations help people understand the meaning of data by placing them in a visual context"

Data visualizations such as bar graphs and scatter plots help people understand the meaning of data by placing them in a visual context. DVTs – scorecards, dashboards, indices and profiles – are interfaces between data and data users that are meant to facilitate decision-making by providing the most critical data for decision-making in a format that is easy to interpret (**Figure 1**).

A common DVT example in everyday life is the car dashboard (**Figure 2**). While there is a lot of information about how a car works, the car dashboard curates the most important actionable indicators that drivers need to facilitate decision-making (e.g., the speedometer tells the driver how fast they are going to help monitor speed).

The landscape of global data visualization tools in nutrition

DataDENT reviewed 22 active global DVTs (defined as DVTs that are publicly accessible and cover multiple countries) in nutrition to understand how these contribute to the nutrition landscape. We developed a framework to review DVTs against four parameters:

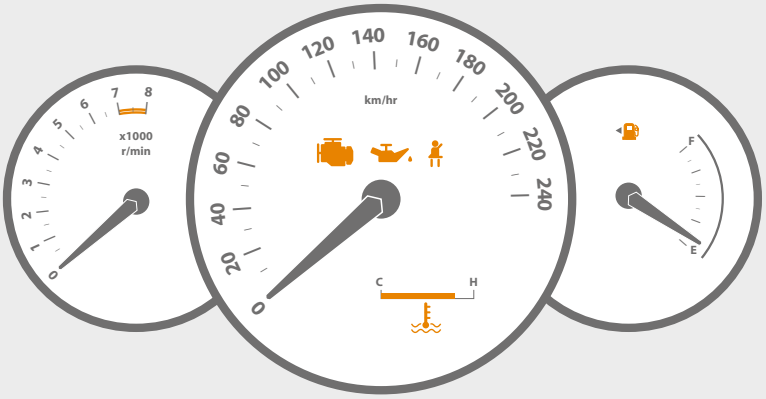
- goals and audience (i.e., accountability, and planning, implementation and monitoring tools);
- domains and indicators (e.g., intervention coverage, nutritional status);
- output structure (i.e., chart types used to visualize data); and
- dissemination (i.e., timing and method of dissemination).

Based on the DVT review, we conducted consultations with select DVT producers to develop case studies (**Figure 3**).

We characterized global DVTs into two categories:

- **Accountability DVTs** – e.g., the Joint Child Malnutrition Estimates interactive dashboard – aim to hold governments accountable for delivering on political commitments or outcomes. These DVTs usually focus on outcome indicators.
- **Planning, implementation and monitoring (PIM) DVTs** – e.g., the Vitamin A Supplementation Dashboard – provide

FIGURE 2: An everyday example: car dashboard versus statistics in a table



Feature	Status
Rotations per minute	0–8,000
Speed	0–240 km/hour
Engine	Operating, malfunction
Oil	Operating, maintenance needed
Seat belt	Fastened, unfastened
Engine temperature	Cold, hot
Gas	Full, empty

FIGURE 3: Global data visualization tools in nutrition reviewed for landscaping

HANCI Country Scorecards

The State of Acute Malnutrition

Nutrition for Growth Accountability Tool

Country Indicators

GLOBAL HUNGER INDEX

Scaling Up NUTRITION SUN Movement Monitoring, Evaluation, Accountability, Learning (MEAL) Country Dashboards

Investing in Nutrition

Global Scorecard of Iodine Nutrition

Global targets tracking tool

NLiS Nutrition Landscape Information System Country Profiles

Countdown Country Dashboards

THE WORLD BANK Nutrition Country Profiles

GLOBAL FOOD SECURITY INDEX 2017

ACCESS TO NUTRITION INDEX™

Global Fortification DATA EXCHANGE

National Anemia Profile

MEASURING PROGRESS TOWARDS ENDING MALNUTRITION

NUTRITION COUNTRY PROFILE

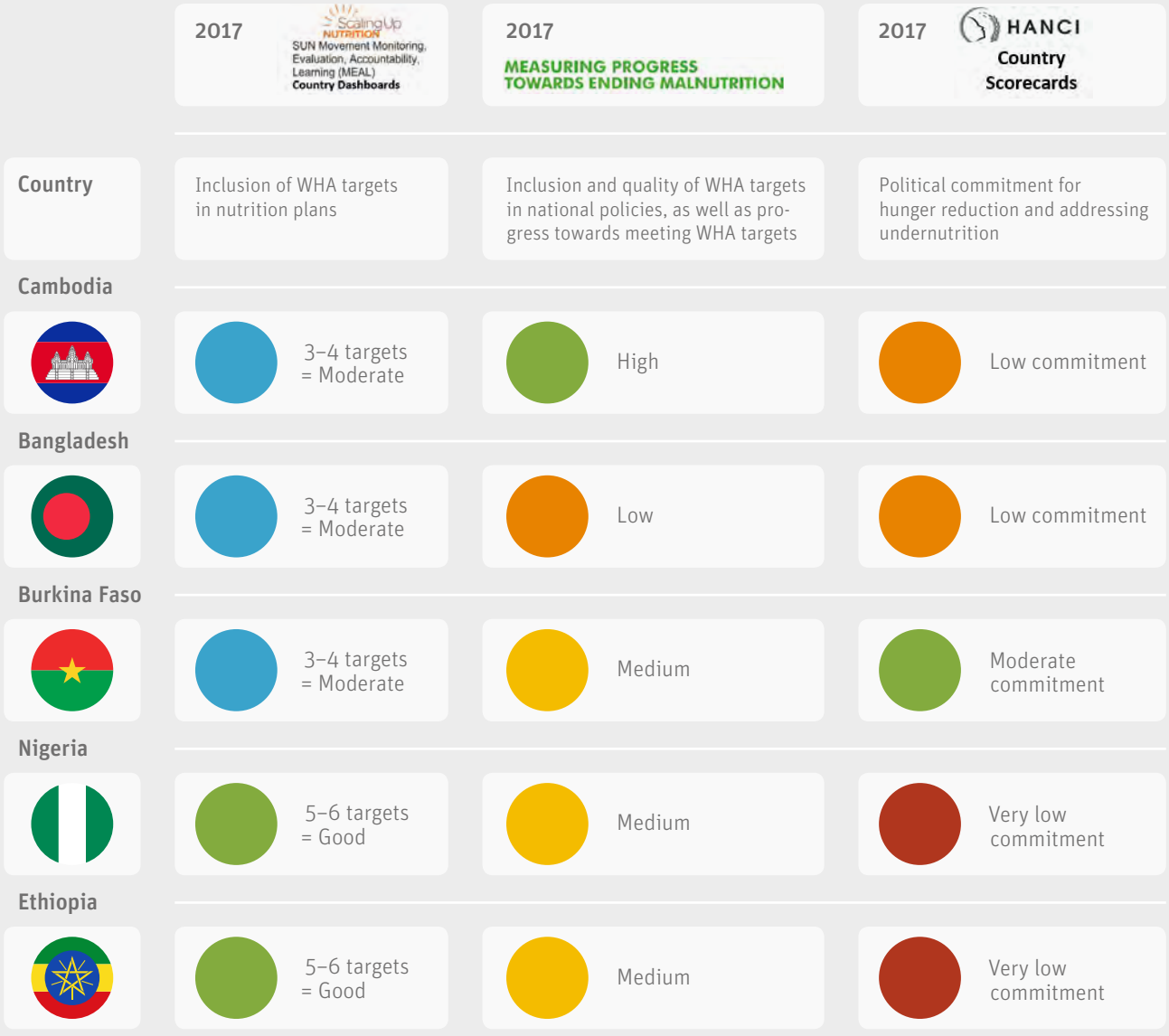
GLOBAL BREASTFEEDING SCORECARD

State of the World's Children Report Dashboard

UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates Interactive Dashboard

Vitamin A supplementation interactive dashboard

FIGURE 4: Political commitment ratings using different definitions for countries across global data visualization tools



data to support a range of stakeholders in planning, implementation and monitoring progress. These DVTs tend to include more actionable indicators.

These two categories are not mutually exclusive, and many global DVTs fall into both categories (e.g., the SUN MEAL country dashboards).

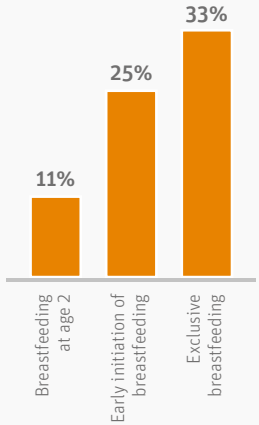
Navigating the growing global data visualization tools landscape

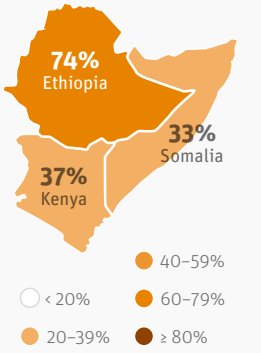
The number of global DVTs in nutrition is increasing. From July 2017 to June 2018, at least 14 global nutrition DVTs were either launched or else refreshed. This growing number may be useful if these DVTs serve different and complementary purposes. But the proliferation may result in fatigue and confusion if there is overlap. Our analysis reveals inefficiencies in the landscape, mainly due to two challenges.

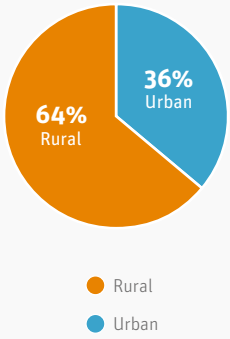
First, many DVTs report the same or similar nutrition indicators with varying definitions (which may be due to a lack of global standard definitions) and years. This can be challenging for funders, country decision-makers or advocates: How can they assess needs and program progress with such different indicators? For example, iron folic acid (IFA) supplementation during pregnancy is a commonly reported indicator across DVTs. Across five DVTs released between 2015 and 2018 reporting data from the 2010 DHS Burkina Faso, four different definitions (any IFA, < 60 days, 60–89 days and 90+ days during pregnancy) were used, resulting in four different statistics ranging from 23 per-

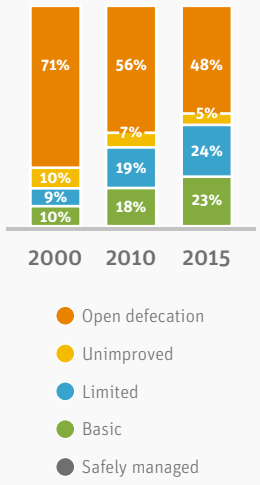
FIGURE 5: Ideal use of data visualizations and current examples in nutrition data visualization tools

	BAR CHARTS	MAPS	PIE CHARTS	STACKED BAR CHARTS
IDEAL USE	› To show a single data point and/or compare values across categories › Generally recommended for use as length is easy to interpret	› To compare values across geographies › Generally recommended for use as other visualizations don't display patterns across a spread over locations as well	› To show parts of a whole › Generally not recommended for use beyond two components as angles are challenging to interpret	› To show parts of a whole › While length is easy to interpret, stacked bar charts may be challenging given components don't share a common baseline
CURRENT EXAMPLES IN NUTRITION DVTS	**Breastfeeding rates in the Congo (%)** (2011–2016)	**Two-dose vitamin A supplementation coverage (%) among 6–59 month olds in East Africa in a calendar year** (2015)	**Rural and urban population (%) in Ecuador** (2017)	**Sanitation coverage (% of population) in Burkina Faso** (2000–2015)
	Source: UNICEF State of the World's Children Interactive Dashboard (2017), from UNICEF 2017	*Source: UNICEF Vitamin A Supplementation Interactive Dashboard (2017), from UNICEF 2017*	*Source: FAO Country Indicators (2017), from FAO 2017*	*Source: Global Nutrition Report Country Profiles (2017), from WHO/UNICEF Joint Monitoring Program 2017*









cent to 93 percent. However, in this case, there is currently no global standard definition for this indicator, which impacts the range of definitions reported.

Second, DVTs use different methodologies and definitions to report similar topics. For example, DVTs commonly use traffic-light color coding based on different definitions. The SUN MEAL, Measuring Progress Towards Ending Malnutrition Scorecard and HANCI include metrics on political commitment for countries but use different definitions. SUN MEAL measures the *existence* of World Health Assembly (WHA) targets in nutrition plans; Measuring Progress Towards Ending Malnutrition Scorecard tracks the *existence and quality* of nutrition targets in national policies, as well as progress towards meeting WHA targets; and HANCI measures *political commitment* to hunger reduction and addresses undernutrition. This results in different ratings, and when viewed together for the same country, likely sends conflicting messages to decision-makers (**Figure 4**).

Tools in action: three key insights from nutrition data visualization tools

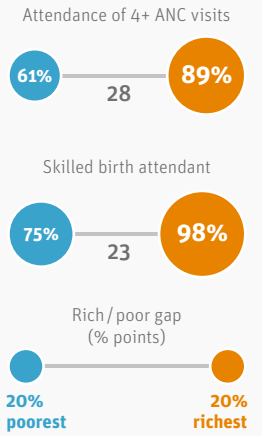
1. Very few DVTs have clear and focused theories of change about the decision(s) they are trying to influence

Making data publicly available to development partners and policymakers with the expectation that it will be used – sometimes known as the 'build-it-and-they-will-come' approach – is common. DVTs in nutrition track many domains, including nutrition policies, financing for nutrition, healthy diets, interventions and progress towards global goals, with little clarity about the DVT's goals and the pathway for change that the DVT is trying

DOT PLOTS

- To show distribution of data points on a scale
- Generally recommended for use as dots on a line are easy to interpret

Attendance of 4+ ANC visits and skilled birth attendant by wealth quintile in Cambodia (2014)



Source: *Countdown to 2030 Country Dashboards (2017), from DHS 2014*

TABLES

- To show data points in an organized structure
- While commonly used, it is not the most engaging visualization method

Anemia prevalence in Afghanistan

Indicator	Year	Value	Source info
Anemia in children < 5 years (Hb < 110 g/L) (%)	2011	44.0%	WHO
Anemia in Nonpregnant women (Hb < 120 g/L) (%)	2016	42.4%	WHO GHO
Anemia in pregnant women (Hb < 110 g/L) (%)	2016	38.2%	WHO GHO

Source: *WHO Nutrition Landscape Information System (2017), from WHO 2011*

to achieve among its targeted audience (which we define as the DVT's 'theory of change').

Without clarity on goals and theory of change, can DVTs prioritize the information they provide and support actions appropriately? Is it possible to assess whether these DVTs are effective?

DVTs with a focused theory of change seem more poised to achieve their goals based on our initial consultations. For instance, the African Leaders Malaria Alliance (ALMA) scorecard is often lauded as a successful DVT for three key reasons. First, it focuses on malaria and targets a select group of decision-makers (i.e., African Heads of States). Second, ALMA measures a select number of the most critical actionable indicators that align with its objectives. Its actionable indicators are flagged with color coding and upward/downward arrows and recommendations are provided to facilitate action. Finally, it has a strong engagement strategy: Heads of States are provided with quarterly progress reports; ALMA regularly adapts its approach based on user feedback; and, when requested, ALMA facilitates connections to provide technical assistance.

> "Outcome indicators such as stunting and wasting present the 'state of nutrition', but are insufficient to support decision-making needs"

2. DVTs could include more actionable indicators to support decision-making

Outcome indicators such as stunting and wasting present the 'state of nutrition', but are insufficient to support decision-making needs. Indicators such as coverage of stunting prevention interventions (e.g., IFA supplementation during pregnancy or complementary feeding counseling) provide the necessary information to take action and improve stunting outcomes.

We define actionable indicators as providing data that can be acted upon to improve performance and management at the program and systems levels. Actionable indicators typically include policy/enabling environment and intervention coverage indicators.

While most DVTs report some actionable indicators, more actionable indicators could be included to support decision-making as per the DVT's theory of change. There are three ways to achieve this:

- if relevant, use actionable indicators that are already collected (and sometimes reported in other DVTs), e.g., *attendance of antenatal care visits (at least four visits);*
- if needed, collect new actionable indicators, e.g., *annual meeting frequency of multisectoral coordination bodies* or *existence of a multisectoral nutrition-costed plan;* and
- for unavailable data, report blank data to trigger discussions on the need for data collection.

3. There are different ways of visualizing data; the choice should be based on the DVT's goals, as well as users' decision needs and data literacy levels

Across nutrition DVTs, several types of visualization are used, including: bar charts, maps, stacked bar charts, pie charts and dot plots – all of which serve different purposes in responding to users' needs (**Figure 5**).[2–4]

It is critical that visualizations align with the DVT's goals as well as users' data literacy levels and decision needs. A study was conducted on reproductive, maternal, newborn and child health, and nutrition decision-makers (defined as program implementers and policymakers) in Tanzania. These decision-makers generally preferred simple visualizations such as bar graphs and pie charts.[5] The study also noted statistical capacity was limited and recommended statistical training to improve data interpretation of advanced data analyses and visualizations. In contrast, nutrition stakeholders with high data literacy and advanced statistics backgrounds may have an easier time leveraging complex DVTs, such as the Global Burden of Disease (GBD) Compare tool, which allows users to change the inputs of risk factors and disease causes against different outcomes (e.g., disability-adjusted life years).

"The growing number of global DVTs in nutrition is a positive reflection of the greater emphasis on data for decision-making, but also a challenge"

Call to action

The growing number of global DVTs in nutrition is a positive reflection of the greater emphasis on data for decision-making, but also a challenge, given the inefficiencies in the DVT landscape.

DVTs can facilitate decision-making among nutrition stakeholders and be powerful instruments for change. However, to increase effectiveness, our initial findings recommend that DVTs should:

- **have a clear theory of change,** articulating which decisions (by which users) the DVT aims to support and what supporting actions are needed to deliver change;
- **include actionable indicators** that align with the DVT's theory of change, including indicators with little to no data for advocacy purposes; and
- **test data visualization formats with targeted users** to ensure formats align with users' data literacy levels and decision needs.

More broadly, there are three potential opportunities for the global community of DVT producers and funders to improve the efficiency of the landscape:

- **Support coordination** among the global DVT community to increase synergies, reduce inefficiencies, and share learnings across DVTs.
- **Convene DVT producers that report on common indicators** to reduce differences in definitions and divergent messages.
- **Strengthen capacity** of targeted users to interpret and use data for decision-making.

Finally, complementing this review, we will be conducting user research among nutrition stakeholders to identify their data needs and how global DVTs respond to them. We will also conduct a DVT landscaping exercise with user research in India to understand how DVTs support country decision-makers in nutrition.

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Practical Guidance on Data Collection and Decision-Making

Home fortification with micronutrient powders (MNPs) containing iron in malaria-endemic regions

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Key messages

- The Home Fortification Technical Advisory Group (HF-TAG) has developed a new technical guidance series designed to help program implementers with data collection and interpretation that can provide key insights to inform decision-making in alignment with WHO guidelines.
- WHO guidelines state that in malaria-endemic areas, the provision of iron to children in any form, including micronutrient powders (MNPs), should be implemented in conjunction with measures to prevent, diagnose and treat malaria.
- The series provides tools and outlines a process that can be broken down into four stages: (1) review of the malaria situation; (2) engagement with malaria program stakeholders; (3) assessment of the malaria program; and (4) determination of readiness to implement or scale up MNPs.

Introduction

The WHO Guideline: Use of Multiple Micronutrient Powders for Point-of-Use Fortification of Foods Consumed by Infants and Young Children Aged 6–23 Months and Children Aged 2–12 Years provides countries with evidence-informed recommendations on the effects and safety of micronutrient powders (MNPs) when considering this intervention to improve the nutritional status of children.[1] Given the wide range of contexts, needs, resources and challenges faced by countries, the WHO guideline also provides important implementation considerations to help in the decision-making process when designing and scaling up interventions.

One of the key considerations highlighted in the WHO guideline is around the implementation of MNPs in malaria-endemic areas due to the potential adverse effects of iron intake among children affected by malaria.[2] The WHO guideline clearly recommends that children 6 months to 12 years of age in malaria-endemic areas are not to be excluded from receiving iron-containing MNPs, as these children are also at risk of significant morbidity, including malnutrition. However, because of the association between anemia and malaria, and due to any po-

During an outreach session in Lao People's Democratic Republic, a woman mixes Super Kid – a locally packed MNP (micronutrient power). Under the program, through outreach efforts, local health center staff travel to local communities in order to provide services and conduct nutrition counseling directly within communities.

tential risks, WHO also recommends that MNPs containing iron should be implemented in conjunction with measures to prevent, diagnose and treat malaria. In order to meet this requirement, the use of MNPs should be coordinated with malaria programs in-country to ensure that the MNP intervention is co-located in the same geographical areas where malaria control strategies are being implemented and where children have access to prompt diagnosis of malaria illness and treatment with effective antimalarial drug therapy.

> "The use of MNPs should be coordinated with malaria programs in-country"

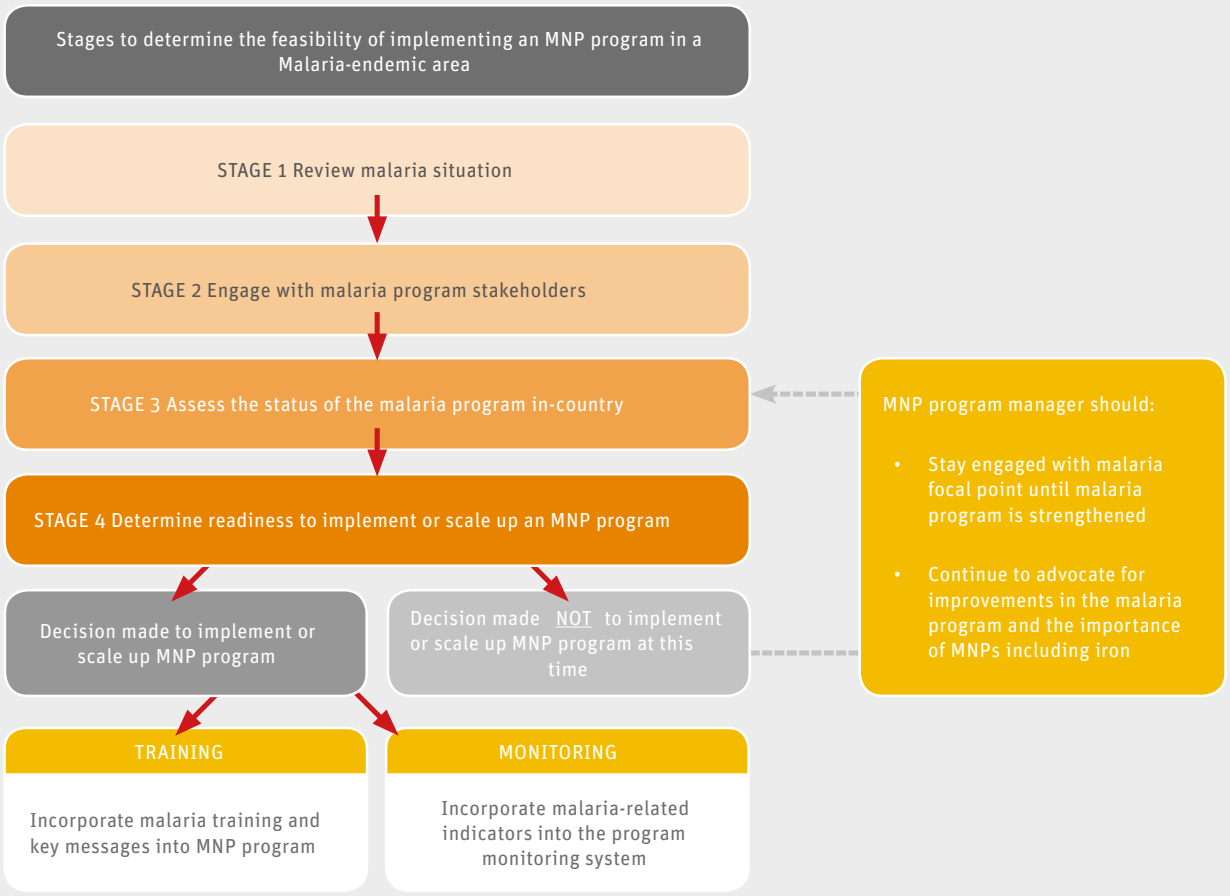
To facilitate operationalization of the WHO guideline at country level, practical guidance and tools have been developed by the Home Fortification Technical Advisory Group (HF-TAG) on how to develop the appropriate strategies to address the use of MNPs containing iron in malaria-endemic regions. These are available on the HF-TAG website.[3] This technical guidance series includes four documents designed to help implementers in collecting and interpreting data that can provide key insights and inform decision-making around the appropriateness, capacity and feasibility to design, implement and scale up MNP interventions. Among the documents included in this series are a technical brief, 'Frequently Asked Questions' (FAQs), and slide decks providing guidance on the interpretation of the WHO World Malaria Report and key messages for the training of health workers.[4] Information provided in these documents is based on literature reviews, country experiences and the opinion of technical experts working in the nutrition and malaria fields.

Audience, aim and approach

The technical guidance series is intended for use by country nutrition program specialists who are planning to implement or are already implementing an MNP intervention in areas where malaria is endemic. For programs in the planning phase, the aim of the guidance is to help in making the decision as to whether and where the MNP intervention can be safely implemented. For programs already distributing MNPs, the aim of the guidance is to help forge stronger links with existing malaria programs and guide the decision as to whether and where to scale up MNP interventions.

The overall approach of the guidance is to break down the data collection, interpretation and decision-making about program design and scale-up into four main stages. **Stage 1** involves conducting an initial review of the malaria situation from existing data; **Stage 2** centers around engaging with malaria

FIGURE 1: Stages to determine the feasibility of implementing an MNP intervention in a malaria-endemic area



Source: Home Fortification Technical Advisory Group

program stakeholders in-country for coordination and co-location; **Stage 3** is an assessment of the status of the malaria program in-country; and **Stage 4** is a determination of the readiness to implement or scale up the MNP intervention (**Figure 1**). Once these stages are followed through by an in-country technical advisory group responsible for decision-making, further guidance is provided on integrating the context-specific information related to malaria and iron into training, behavior change communication and monitoring systems of the country.

"Children receiving MNP should have access to malaria prevention strategies, prompt diagnosis of malaria illness, and treatment with effective anti-malarial drug therapy"

Stage 1: Conduct an initial review of the malaria situation

This stage involves the collection of data that will provide an initial review and snapshot of national and, if available, regional, state/province or district level policies on malaria prevention and control in the country of interest. For nutrition specialists who may not be as familiar with malaria programming, the guidance also provides an outline and description of the main pillars of malaria control programs, including vector control (primarily the use of insecticide-treated nets [ITNs]), seasonal malaria chemoprevention, and case management (involving parasitologic diagnosis and treatment with an effective artemisinin-based combination therapy [ACT]). The initial source for data collection recommended to program implementers is the World Malaria Report (WMR) published annually by the World Health Organization (WHO), which includes data for 12 globally relevant indicators against which progress in malaria control and elimination can be monitored. Data is also presented by the WMR in the format of one-page country profiles, which provide a summary of the main malaria interventions and WHO-recom-

mended policies that are in place. A presentation tool entitled 'Interpretation of the World Malaria Report Country Profile' is provided by the HF-TAG, including an example of a country profile that has been annotated with guidance notes and explanations (Figure 2).[5]

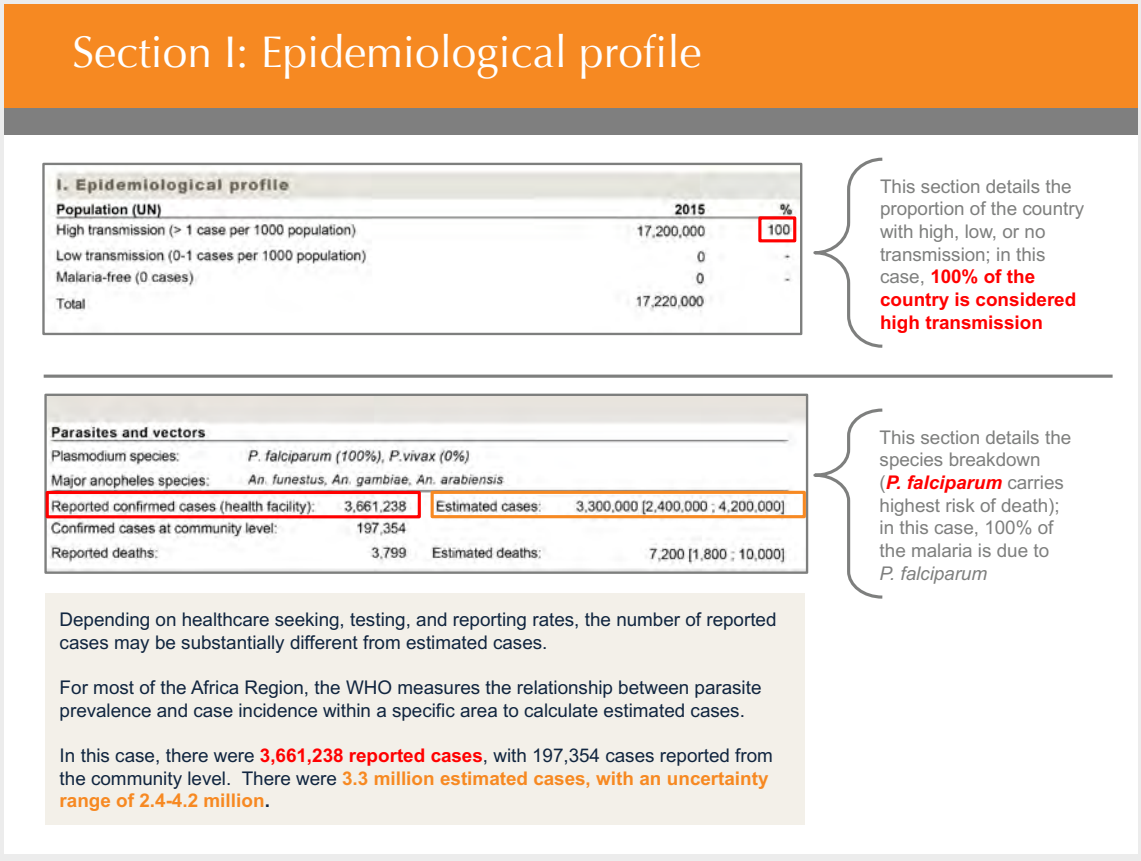
Stage 2: Identify and engage with malaria program stakeholders

Children receiving MNPs should have access to malaria prevention strategies, prompt diagnosis of malaria illness and treatment with effective antimalarial drug therapy. Therefore, to ensure the co-location of an MNP intervention in the same geographical area as a malaria control program, effective coordination and engagement between nutrition and malaria stakeholders in the country is required. One of the key tasks outlined in the guidance is who to engage as a malaria focal person, as well as how to engage them as active members on an MNP technical advisory group. This includes sharing updates on malaria program indicators and other activities relevant to the MNP intervention. A key role of the malaria focal person will be to help gather malaria program information and data, interpret that information in the next stage (Stage 3) and assist with the decision-making process.

Stage 3: Assess the status of the malaria program in-country

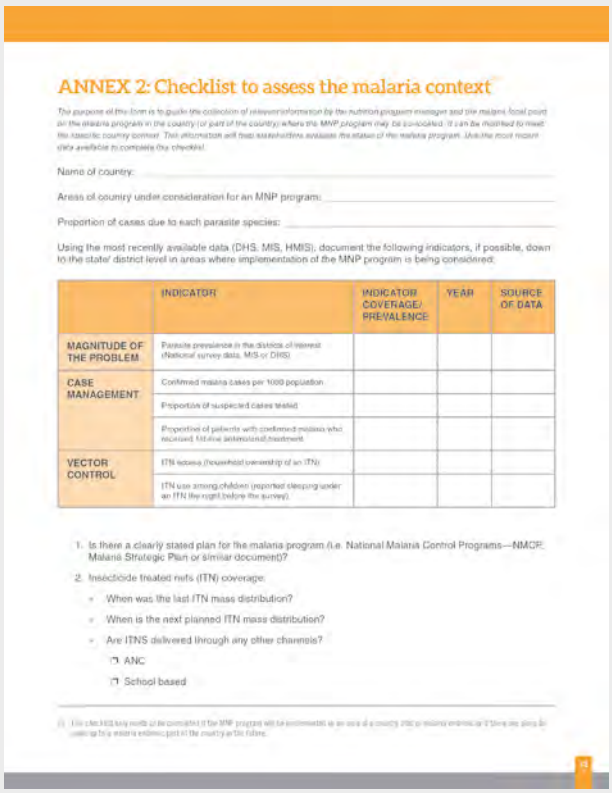
Stage 3, which determines the feasibility of implementing an MNP intervention within a malaria-endemic area, involves a more detailed review of the data and information initially collected in Stage 1. This detailed assessment should be a collaborative effort between the nutrition and malaria teams and should include a review of the status of the malaria program in the country, as well as an assessment of the level or degree of implementation. Here, the HF-TAG provides a tool in the form of a checklist that will guide the collection of relevant data and information, ideally focusing on the area of the country where MNPs are to be implemented (Figure 3). To account for any in-country variance, the level of data disaggregation for the assessment should begin at the national level and then proceed to

FIGURE 2: Example of annotated presentation, developed to help explain the components of the World Malaria Report Country Profile



Source: Home Fortification Technical Advisory Group

FIGURE 3: First page of the checklist tool to assess the malaria context



ANNEX 2: Checklist to assess the malaria context

Name of country:

Areas of country under consideration for an MNP program:

Proportion of cases due to each parasite species:

Using the most recently available data (DHS, MIS, HMIS), document the following indicators, if possible, down to the state/ district level in areas where implementation of the MNP program is being considered:

	INDICATOR	INDICATOR COVERAGE/ PREVALENCE	YEAR	SOURCE OF DATA
MAGNITUDE OF THE PROBLEM	Parasite prevalence in the district of interest (National survey data, MIS or DHS)			
CASE MANAGEMENT	Confirmed malaria cases per 1000 population			
	Proportion of suspected cases tested			
	Proportion of patients with confirmed malaria who received first-line antimalarial treatment			
VECTOR CONTROL	ITN access (household ownership of an ITN)			
	ITN use among children (reported sleeping under an ITN the night before the survey)			

1. Is there a clearly stated plan for the malaria program (i.e. National Malaria Control Programs—NMCP, Malaria Strategic Plan or similar document)?
2. Insecticide treated nets (ITN) coverage:
   - When was the last ITN mass distribution?
   - When is the next planned ITN mass distribution?
   - Are ITNS delivered through any other channels?
     - ☐ ANC
     - ☐ School based

Source: Home Fortification Technical Advisory Group

the appropriate level of decision-making, whether it be state/ province level or district level.

> "One of the components of the decision pathway requires interpreting the data to confirm whether a malaria program is 'active'"

Stage 4: Determine readiness to implement or scale up an MNP program

The purpose of Stage 4 is to provide implementers with a framework to assess the readiness to implement or scale up an MNP intervention. A decision pathway is provided as guidance that incorporates the data and information collected from the preceding stages (**Figure 4**).

To ensure that the provision of MNPs is done in conjunction with public health measures to prevent, diagnose and treat malaria, one of the components of the decision pathway requires interpreting the data to confirm whether a malaria program is 'active.' Although there are no internationally defined benchmarks by which to decide if a program is operating adequately, for the purpose of this guidance, the HF-TAG defines an 'active' program as one where all elements of malaria control are being implemented, namely prevention, diagnosis and treatment. Furthermore, the malaria program should be considered stable or improving, with no anticipated challenges including funding gaps or substantial reductions in funding that can have a negative impact on operations.

Conclusions

After following the four stages and taking into account the country-specific data and information collected, the decision pathway should guide the MNPs technical advisory team to reach a decision on whether or not to proceed with the implementation or scale-up of the MNP intervention. Such a decision is generally taken in conjunction with the country's Ministry of Health or appropriate authority. If a decision is made to proceed with implementing or scaling up the MNP intervention, then information related to malaria and iron supplementation should be incorporated into the following program components: **(1)** training of healthcare workers and any other frontline workers dealing directly with program recipients; **(2)** behavior change communication materials targeted at program beneficiaries; and **(3)** relevant indicators (including malaria indicators) within the program monitoring system. The technical guidance provides further recommendations and tools to support these actions.[6] In addition, the HF-TAG resource Planning for Program Implementation of Home Fortification with Micronutrient Powders (MNP): A Step-by-Step Manual provides detailed guidance on the planning and implementation of MNP interventions that implementers can reference.[7]

In the case where the decision-making pathway and review of the data demonstrate that the MNP intervention may not be appropriate within the given context, it is suggested that the nutrition and malaria teams continue to discuss and collaborate on ways to strengthen the malaria program in the areas of interest. This should also include planning for a repeat of stages 1–4 as a reassessment to determine if conditions have improved sufficiently for the implementation or scaling-up of the MNP intervention.

Finally, while the practical guidance described here supports data collection essential to evidence-informed decision-making, the series also provides an accompanying resource to address common technical considerations based on reviews of the literature and the opinion of technical experts in the fields of nutrition and malaria. For example, answers to questions related to the following can be found under 'FAQs': what is known about the

provision of iron supplements (including MNPs) to children at risk of illness from malaria; what is known about the safety of MNPs at varying levels of coverage of ITNs; and what is known about the relationship between folic acid intake and the efficacy of malaria treatment.[8] The HF-TAG will continue to follow the research development of MNPs and update the series periodically as new data become available. The development of technical guidance in this manner (i.e. collaboration between nutrition and malaria programs) highlights the importance of intersectoral coordination, in which data collection is an essential component in the decision-making process, and may be helpful in promoting synergies between other public health interventions.

> "The HF-TAG will continue to follow the research development of MNPs and update the series periodically"

Acknowledgements

Partners involved in the Home Fortification Technical Advisory Group (HF-TAG) and the development of the technical guidance series mentioned in this article include: US Centers for Disease Control and Prevention; Global Alliance for Improved Nutrition; Nutrition International; *Sight and Life*; The Hospital for Sick Children, Centre for Global Child Health; UNICEF; UC Davis Program in International and Community Nutrition; World Food Programme; and World Bank Group.

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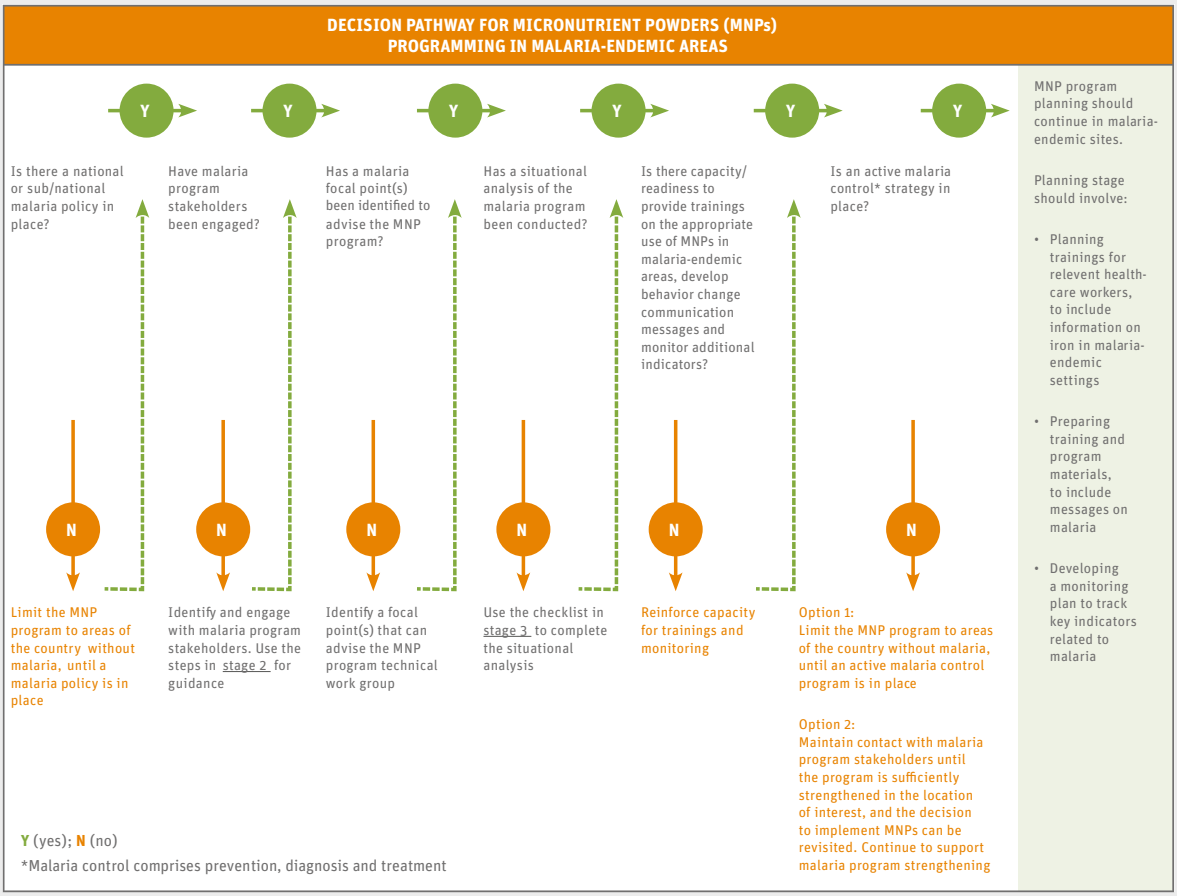
FIGURE 4 Decision pathway for micronutrient powders programming in malaria-endemic areas



Source: Home Fortification Technical Advisory Group

This mother and her 2-year-old child in the northeast of Côte d'Ivoire have been sleeping under mosquito nets to reduce the chances of contracting malaria

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Considering Ethics Along the Data Value Chain for Nutrition

Jessica Fanzo
Johns Hopkins University, Washington, DC, USA

Key messages

- There are several ethical issues that need to be taken into consideration when prioritizing, collecting, analyzing and disseminating data across the *nutrition data value chain*. These include favoring public health good over gathering data for data's sake, considering individual rights over public interests, and ensuring accountability and transparency of data sharing and publication.
- While nutrition evidence is building, the *precautionary principle* – whereby decisions to act are taken on issues even though extensive scientific knowledge on the matter is lacking or uncertain – should be carefully analyzed.
- We are living in a time of 'big data' that is piggybacking on the digital age and economy and on social media interfaces. For those collecting, curating and using that data, there should be a form of global *Hippocratic oath* in place to "do no harm," protect human dignity and promote wellbeing over profit interests.
- We need to account for the *downstream uses of nutrition*, as well as dietary intake and behavior data, in ways that are consistent with the intentions and understanding of the disclosers who provide personal information to researchers.

Introduction

The 2017 Global Nutrition Report called for revolutionizing efforts across the nutrition data value chain. This chain includes data priority-setting, collection, analysis, interpretation and use of information by decision-makers working in the nutrition space.[1] It proposed to position data as a *value product* to address malnutrition in all its forms.

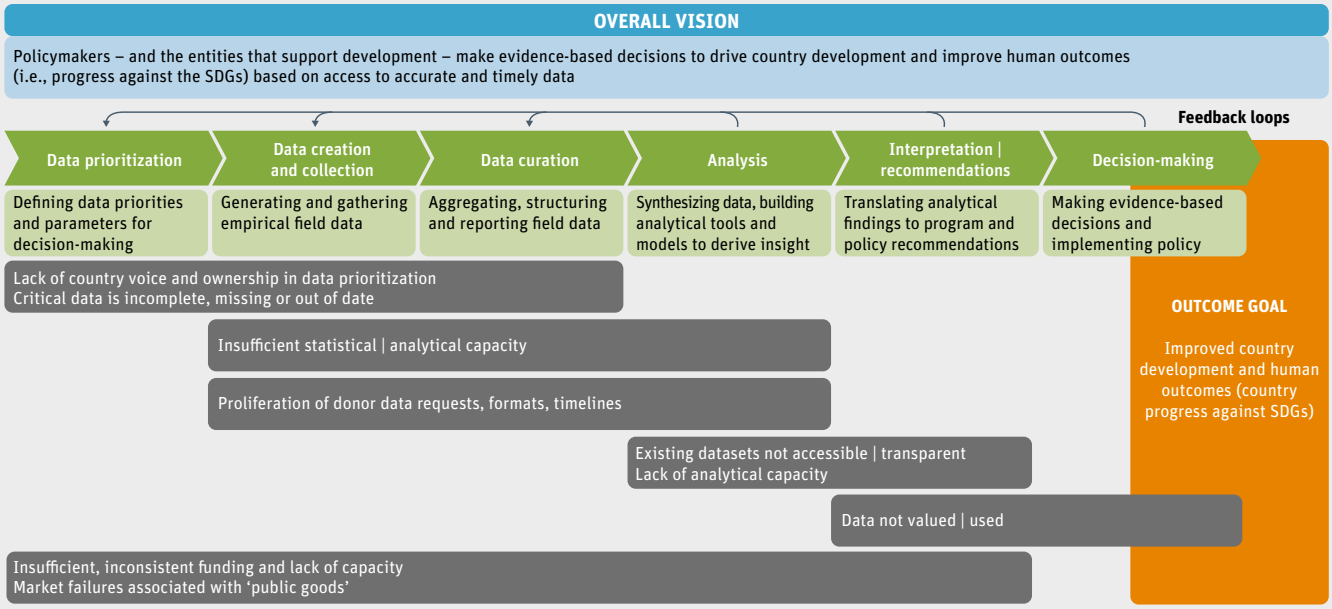
The data value chain highlighted six critical steps as shown in **Figure 1** and called for an agenda that requires: "**1)** in-country mechanisms for national priority-setting and data coordination; **2)** operational guidance for data prioritization, harmonization of indicators, and incorporation of nutrition into routine management information systems; **3)** tools for capacity development at multiple levels; **4)** costed data plans that are built into national development strategies, resourced and implemented; **5)** dissemination of tacit knowledge and experience; **6)** innovation across the value chain; and **7)** fostering a culture of data use and sharing."

Considering ethics along the data value chain for nutrition

To undertake this revolution, there are certain *ethical* issues that should also be considered across the entirety of the nutrition data value chain. In collecting any kind of data, there are, of course, guiding ethical principles and values that should be maintained, including autonomy and confidentiality of those whose personal information is used to garner evidence that informs programs and policies. However, other ethical considerations should also be considered when prioritizing, collecting, analyzing and disseminating data, such as issues around favoring public health good over gathering data for data's sake, considering individual rights over public interests, and ensuring accountability and transparency of data sharing.

The 1978 landmark Belmont Report,[2] an essential reference tool for almost all institutional review boards (IRBs), provided ethical guidance on doing research involving human subjects and highlighted three core principles: respect for persons (protecting autonomy, ensuring respect and avoiding deception); beneficence of populations/persons (maximizing benefits and minimizing risks); and justice to research participants (fair and equal distribution of costs and benefits). To carry out these principles, informed consent, assessment of risks and benefits for human populations and selection criteria of human subjects should be required across research. Many of these same principles can be applied across the data value chain.

FIGURE 1: The data value chain for nutrition



Source: Development Initiatives, 2017[1]

> "The Belmont Report highlighted three core principles: respect for persons, beneficence of populations | persons, and justice to research participants"

In this piece, three issues that cut across the data value chain in nutrition are highlighted, including: **1)** the precautionary principle conundrum; **2)** the Hippocratic oath of big data curation; and **3)** the sensitivity of analysis and usage of data. Thereafter, a set of questions is presented that can serve as a starting point to dive deeper into specific ethical concerns at each stage of the value chain.[3]

The precautionary principle conundrum

In the case of nutrition, there is often an assertion that "we need more evidence" before we take action. But what if there is not enough evidence available? And when is enough, enough? When do we determine that what we have in hand is sufficient? While monitoring and evaluation are essential for guiding nutrition policies or programs, there are still interventions that have not undergone extensive evaluation to assess their impact in different contexts and in different populations. This leaves policymakers and development practitioners working somewhat in the dark, without guidance to determine what constitutes sound evidence to justify an intervention, and what factors must be considered within such an evaluation. Interventions "should be implemented only in the face of a clear public health need and good data demonstrating effectiveness."[4]

One cannot underestimate the complexities of the multiple forms of malnutrition, which not only have multiple causes – both immediate and underlying – but also have varying impacts at different stages of the life cycle. Because of these complexities, there are still gaps in evidence and knowledge. These gaps prevent implementation of critical nutrition interventions.[4] This brings into consideration the *precautionary principle* in cases where decisions to act are taken on issues even though extensive scientific knowledge on the matter is lacking or uncertain. Policymakers can justify these decisions in situations where there is a social responsibility to protect the public from exposure to harm (because of a plausible risk) as opposed to not taking any action.

For example, while the nutrition community does not have all the evidence to hand of the impact of diets on health outcomes, some data suggests that certain dietary patterns promote health and that certain foods can cause deleterious health outcomes. The precautionary principle can be used in this case to draft dietary guidelines or provide dietary advice to citizens that can generally maximize health and minimize harm. For example, consumption of fruits and vegetables is most likely beneficial to human health.[5]

The Hippocratic oath of big data curation

We are living in a time of 'big data' that is piggybacking on the digital age and economy and the incredible breadth of information being collected across social media platforms. These big data include massive streams of information points being collected, combined and shared. Undoubtedly, big data will play an important role in delivering a deeper understanding of populations, revealing individual drivers of choice concerning what they eat, purchase and aspire to. Much of this data provides personalized nutrition insights and indicates how decisions are made, from farm to markets to individuals, and from genome to metabolome. But this personalization can create entirely new types of ethical risk concerning who is using the data and how it is disseminated. Risks include unethical or illegal use for purposes for which the original disclosers did not give their consent.[6]

There is an absolute need for oversight of these data and for sound governance, with clear transparency and accountability mechanisms. Making data open access, allowing for further analysis and interpretation of data by other parties (e.g., repeating results), and publishing 'null' results on research outcomes are all key to ensuring transparency and accountability in nutrition.[7] Right now, there is a lack of authority and accompanying legislation to enforce rules of ethical practice in the use of big data. For those collecting, curating and using that data, there should perhaps be a form of global *Hippocratic oath* in place. This oath should be to "do no harm," to protect human dignity and to promote wellbeing over profit interests. Above all, data scientists and operators of these large platforms should respect the privacy of individuals and put the people behind the data above any other objective.

> "For those collecting, curating and using that data, there should perhaps be form of global *Hippocratic oath* in place"

For example, many people are now posting details about what they eat on Facebook, Twitter or Instagram. This could be a valuable resource in understanding what consumers like to eat, what drives their eating behaviors and what potential products they may buy. While it is enticing to use these social platforms for data purposes, most users of these social platforms share information because they want the content to reflect their online identity, they want to grow and nourish relationships, they like the feeling of having others comment on their status or they want to spread the word about an issue they care about.[8] Most users are not posting their information for the purposes of profit by others. Thus, it is important for these social media platforms to govern the data. Governance comes in the form of being transparent on how the data is used or sold, obtaining consent from data disclosers, instilling additional data privacy measures that data disclosers can opt in/out of, and minimizing the sale of data to third-party users.

The sensitivity of analysis and usage of data

We need to account for the downstream uses of datasets, including not only primary data collected by researchers but also secondary data analysis collected by others (e.g., using data from the Demographic and Health Surveys). Data starts as 'raw', but data analytics and interpretation carry a "history of human decision-making" that should be trackable and transparent regardless of whether it is primary data or secondary data analysis.[1,9,10] This would again include accountability mechanisms for collecting data, the methods to do so, the consent for use of that data, and how data is analyzed and assessed. However, sometimes data is repurposed (e.g., secondary data analysis), which creates significant ethical risk. Researchers should strive to use data in ways that are consistent with the intentions and understanding of the data disclosers who provide personal information to the original investigators.[9]

For example, the practice of qualitative secondary analysis has been accompanied by some ethical controversy, because it involves different relationships between researchers and participants as compared with primary research data collection.[11] With primary data generation, "data is collected through trust interactions between researchers and participants and is shaped in ways which relate to the project design, researchers' disciplinary assumptions, theoretical inclinations and methodological decisions."[12] This garners concern about how the data may be used by others at a later date, and about the consent to use that data in different ways and for different purposes. Where the future use of data is not clear, it is important to secure informed consent using generic statements about how the data will be used, as well as the respective obligations or duties of research participants, primary and secondary researchers, project partners such as service providers, and also the general public.[12]

The Young Lives project – a longitudinal, international study with publicly archived survey data, exploring childhood poverty over time, including nutrition outcomes – undertook an assessment of the ethical implications of secondary analysis of qualitative data collected in the project. The authors argue that while sharing data for the purposes of secondary analysis brings many benefits, it also can be ethically complex.[13] Issues to be addressed include countering risks of misinterpretation, proper informed consent, using data far from the intentions of the project and improper use of data representation in media dissemination. The authors argue, as does Irwin,[11] that devel-

TABLE 1: Ethical questions across the data value chain in nutrition

Value chain step	Ethical questions
Data prioritization, creation and collection	> Has the data collection procedure gone through an ethics review process?
	> Given the different types of data being collected, what potential harm could come from using that data?
	> Is there a way to minimize the volume or variety of data being collected by streamlining surveys, using secondary data and reviewing the essentiality of data in order to understand key research questions?
	> Are data disclosers (those whose information is being collected) aware that data has been acquired, stored or shared?
	> Will the data being collected, or the analysis of that data, be shared with the data disclosers?
Data curation and analysis	> Are there any potential harms if others access the data or the analysis of that data?
	> What negative consequences for the data discloser could result from the proposed analysis? What steps are being taken to mitigate these risks?
	> What biases have been introduced during the analysis of data and how were they addressed?
	> How frequently should an ethics assessment be performed on these analyses for alignment with project, product and service goals and the organization's code of ethics?
Data interpretation, use and decision-making	> Did the data discloser provide consent to this specific data use? Was that consent informed?
	> Can a data discloser discover whether data they have disclosed has been used and for what purpose?
	> Are there mechanisms in place for controlling access to the data?
	> What measures are taken to account for the risk and/or harm that could come from misusing the data?
	> Do data disclosers expect control, ownership, remuneration or transparency over the data they have disclosed if it is being shared? Did they provide informed consent for this action?

Source: Adapted from Accenture Labs 2016[3,14]

oping and maintaining trusting relationships between research participants and primary and secondary researchers are key to avoiding unethical use of data.[13]

Ethical assessment across the data value chain

Introducing an ethics assessment at each stage of the data value chain can provide new perspectives of how data is being used. The questions in Table 1 can act as a starting point for project implementers or policy analysts to dive deeper into specific ethical concerns at each stage.

> "If we consider the principles of the Belmont Report, the risks can be mitigated"

Conclusion

We are living in an exciting time. Evidence is ramping up. There are more metrics and indicators to collect valuable information on diets, nutrition and other nutrition-related factors and inputs. There is more data out there – from traditional surveys to big data on social media. However, these developments also present new risks regarding the way data is collected, interpreted, used and shared. Some of these risks present ethical dilemmas. However, if we consider the three principles of the landmark 1978 Belmont Report[2] – beneficence, justice and respect for persons – in the data value chain in nutrition, the risks can be mitigated.

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For a world free from malnutrition.

Sight and Life is a nutrition think tank supported by DSM

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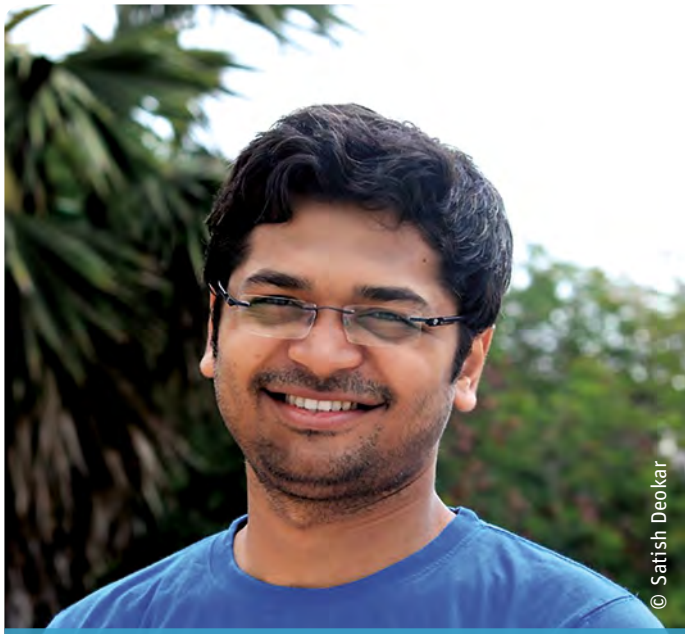
A Day in the Life of Shantanu Pathak

Shantanu Pathak is the co-founder of CareNX Innovations Pvt Ltd, a pregnancy care company based in Navi Mumbai (New Bombay), India. CareNX Innovations offers digital health solutions to healthcare providers to improve healthcare delivery and help lay the foundations for healthier generations to come. He explains to *Sight and Life* how he has dedicated his life to the cause of preventive medicine.



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Shantanu Pathak, co-founder and CEO of CareNX Innovations

***Sight and Life* (SAL):** *Shantanu, what was the inspiration behind the creation of CareNX Innovations?*

Shantanu Pathak (SP): It was ultimately my own experience in coming from a family of patients. I lost my father when I was 13 years old. To this day, I don't know why and how my father died, because his death was not documented. The documents that might tell me the cause of death literally do not exist. My awareness of this made me realize the extreme importance of documentation in medicine, and it prompted me to see the world in a completely new way.

I was aware that mortality rates among pregnant women in India were unacceptably high. I have a Bachelor's Degree in Engineering, Electronics and Telecommunications from the University of Mumbai and a PhD in Biomedical Engineering from the Indian Institute of Technology, Bombay. With my interest in telecommunications and the internet, I could imagine how these new technologies could be applied to the biomedical field in personalized form. That was the inspiration behind the foundation of CareNX Innovations.

My co-founder Aditya Kulkarni and I conducted a small pilot in a little village in the state of Maharashtra in Western India. Its success inspired us to take the idea further, but we didn't want to become an organization that would be dependent on external funding for its lifetime. We therefore opted for the entrepreneurial route, with a view to developing solutions that would deliver benefits not only for India but for populations around the world. Equipping frontline medical workers with innovative technological solutions was fundamental to our approach.

SAL: *The use of technology in delivering healthcare is growing worldwide. What is special about the way you deploy it in the context of India?*

SP: Healthcare in India, and indeed worldwide, is a service sector. Healthcare is provided to people by other people, and India is very dependent on its healthcare facilities and professionals. However, with ratios of one doctor to 10,000 people and one gynecologist to 3,000 pregnant women, there is a clear need to move from purely curative to preventive medicine if this load is to be managed at all.

Frontline workers have a critical role to play here, and they can operate much more effectively if they are equipped with the right tools. Technology is essential to increase our capability in developing preventive medicine and coping with the medical

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CareNX's co-founders, photographed at the company's offices in Navi Mumbai: Aditya Kulkarni (left) and Shantanu Pathak (right)

challenges of pregnancy and noncommunicable diseases at a more manageable cost.

> "Frontline workers have a critical role to play if they are equipped with the right tools"

SAL: *What are the key products and services of CareNX Innovations, and who are the prime beneficiaries of this offering?*

SP: We are a pregnancy care company that offers solutions for pregnant mothers in both private and public healthcare settings. One of our main offerings is CareMother, a portable kit and mobile application to empower health workers and engage pregnant women. We call this a 'doorstep care platform'. A health worker carrying a CareMother kit can perform essential screening checks on expecting mothers literally on their doorstep. Should the tests reveal increased health risks to mother and/or baby, the patient will be referred to a doctor for consultation.

The doctor performing this consultation may of course not be a gynecologist. If he or she has concerns about the patient's health and lacks the necessary gynecological expertise to make an appropriate intervention, then he or she will refer the patient to a specialist. The beauty of this system lies in the simple and effective triaging of medical cases on the basis of a few preliminary diagnostic tests performed in the home rather than at hospital. The outcome is a significant increase in the rate of safe hospital deliveries in the case of at-risk mothers and babies.

> "The beauty of this system lies in the simple and effective triaging of medical cases on the basis of a few preliminary diagnostic tests"

Another of our leading products is Fetosense, a smartphone-based fetal heart monitoring solution. India tops the list of countries for preterm deliveries, stillbirths and early infant mortality. We have many programs focusing on hemoglobin and iron levels, but our healthcare workers are not trained to focus on the final trimester of pregnancy, and especially not on fetal wellness. The Fetosense device helps monitor fetal heart and contraction and is associated with a smartphone app. The test results are visible to an expert anywhere in the world through this app, thus enabling remote monitoring.

We are also working together with *Sight and Life* on a new solution for personalized nutrition monitoring and intervention to counter malnutrition. This new technology, which uses artificial intelligence, is currently in the R&D stage, and results to date have been very promising. We submitted this concept for the *Sight and Life* Elevator Pitch Contest at the Micronutrient Forum held in Cancún, Mexico, 24–28 October 2016, which was jointly sponsored by *Sight and Life* and the Tata Trusts. The contest was designed to stimulate fresh thinking about micronutrient innovation and entrepreneurship among students. We featured among the 10 finalists.


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Ms Pritee Dehukar, a trainer from CareNX, trains health workers in CareMother technology at Apnalaya's Health Center in Mumbai. Live demonstrations of how to use point-of-care devices form part of the training of health workers.

SAL: *What have been the main challenges in establishing CareNX Innovations and developing it to its current size, Shantanu?*

SP: In order to have any prospects of success, my partner Aditya and I needed to develop a good understanding both of the healthcare sector and of business in general. This was a challenge for us – not least because neither of us comes from a business background. We had to work hard with complex government organizations in order to persuade people to think in new ways, and we also had to attract talented people who could deliver on the concepts we had developed. Above and beyond that, we had the perennial challenge of coming up with a good plan, sticking to it and implementing it successfully. Technology can make the world a better place, but only if it is used appropriately. As a company, we're ultimately dependent on the doctors and front-line workers who use our products. And so we had to ensure that our products were really easy to use.

SAL: *You have won numerous awards for your work as a technology innovator. What do these awards mean to you, and is there one of which you are particularly proud?*

SP: Every award is helpful, because it allows us to obtain essential funding, to meet potential mentors and also to encounter like-minded people from whom we can learn. Particularly inspiring was receiving The President of India's Innovation Scholar Award in 2015, and later Aditya receiving a Queen's Young Leader Award from Her Majesty The Queen at Buckingham Palace in June 2018.

SAL: *Are innovators born or made, in your opinion, Shantanu?*

SP: I think that innovators are both born and made. Being an innovator is like being an artist: you have to be a good performer as well. You may have the intellect and the imagination necessary to conceive a new idea, but innovation is a journey, and you need a lot of passion to stick at it and turn your theoretical concept into a practical solution.

> "Being an innovator is being like an artist: you have to be a good performer as well"

SAL: *And entrepreneurs …?*

SP: Entrepreneurs are also shaped by the journey that they undertake, so they are made. It requires a strong sense of purpose that goes far beyond just making money. It's a great career if one likes adventure, being challenged and being pushed to one's limits.

SAL: *Which invention from history would you most like to have developed yourself?*

SP: I think I would like to have developed the electric lightbulb, for example, or the telephone: those two inventions really transformed the world. However, what is really important to me today is to develop innovations that make people healthier and happier.

SAL: *Do you have a particular hero or role model, whether real or fictional?*

SP: My brother, who today is a plant manager in the steel industry, is my hero. I felt very stressed and indeed depressed during my first and second years of studying Engineering, but my brother really helped me. He's extremely good at making decisions, and he helped me get my confidence and my studies back on track.

SAL: *Do you have a personal philosophy or mantra?*

SP: I believe that small is beautiful – by which I mean that it's essential to include people in your thinking, to understand the importance of small things, and not to be greedy. Small and simple things can make a great difference.

SAL: *Thank you, Shantanu, and the best of luck with your endeavors!*

SP: Thank you.

Shantanu Pathak *was interviewed by Jonathan Steffen*

Care worker in action

Papitha Lokhande, Apnalaya health worker

Papitha Lokhande has been a frontline health worker for the past 6 years. She recounts how CareMother made it possible for a mother in the final month of pregnancy to be admitted to hospital for the delivery of her baby.

"One of my patients was a woman who lived in a slum where every day is a new challenge. During the ninth month of her pregnancy, a thief stole her handbag, which contained a file with all the documentation relating to her pregnancy, including the unique patient number which is required for admission to hospital. She was in labor and needed this number to get admitted. As you may imagine, this woman was very distressed at the loss. When she reported it to me, I went to the hospital with her and was able to show the medical staff photos of the stolen documents which I had previously stored in the CareMother app. Once the number and reports were presented, the woman could be admitted to hospital for safe delivery of her child."

Doorstep visit for an antenatal check-up and counseling by Ms Papitha in Mumbai slums. A mother shows her medical reports to Ms Papitha, and with the help of the CareMother application, Ms Papitha provides counseling on high-risk pregnancies.

Special Feature

Diets for a Complex World: The Search for Wholeness

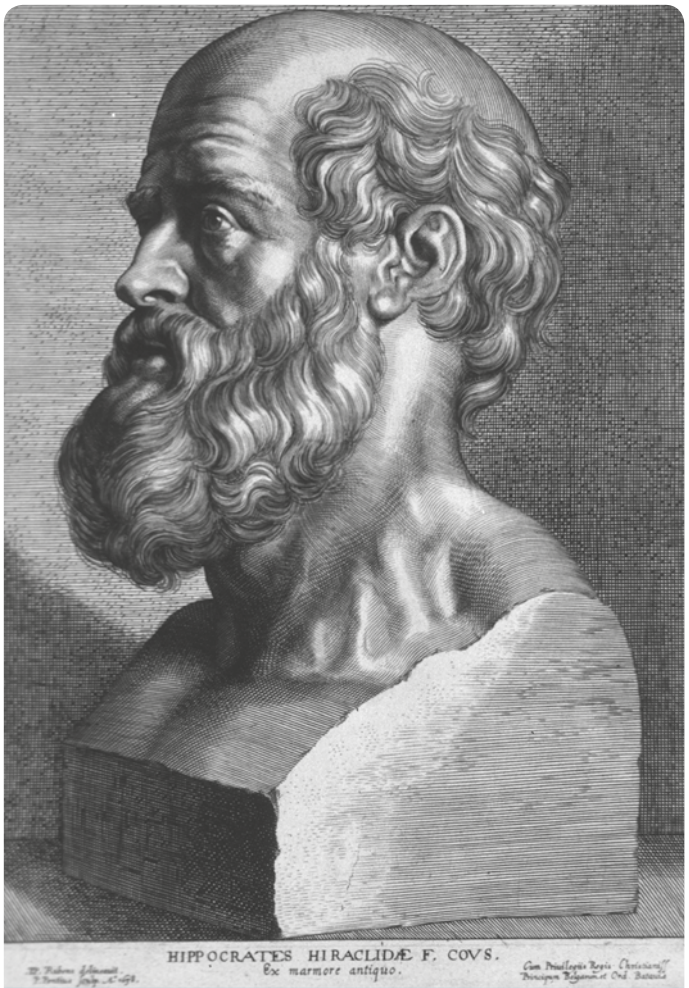
Jonathan Steffen
Jonathan Steffen Limited, Cambridge, UK

At the beginning of 2019, the EAT–Lancet Commission published Food in the Anthropocene, a consideration of healthy diets from sustainable food systems.[1] The authors observed that "A healthy diet should optimize health, defined broadly as being a state of complete physical, mental and social well-being and not merely the absence of disease,"[2] emphasizing that the scientific targets for the healthy diets advocated in the report were "based on the extensive literature on foods, dietary patterns and health outcomes."

The report considers in detail the relationship between the construction of diets and the production of food. "How food is produced, what is consumed, and how much is lost or wasted all heavily shape the health of both people and planet. The EAT–Lancet Commission presents an integrated global framework and for the first time, aims to provide quantitative scientific targets for healthy diets and sustainable food production. The Commission shows that feeding 10 billion people a healthy diet within safe planetary boundaries for food production by 2050 is both possible and necessary. The data are both sufficient and strong enough to warrant immediate action."[2]

> "The EAT–Lancet Commission shows that feeding 10 billion people a healthy diet within safe planetary boundaries for food production by 2050 is both possible and necessary"

Significantly, the words *diet* and *data* appear in the same paragraph here. Any effective approach to fixing the world's food systems issues and meeting the nutritional needs of the burgeoning global population must be evidence-based and data-driven. Equally significantly, the report advocates diets that support "a state of complete physical, mental and social well-being and not merely the absence of disease". Diet, data and wellbeing in its broadest sense are brought together in one line of thought. If this appears absolutely up to the minute, it is – in the sense that the Ancient Greeks were absolutely up to the minute.



The Greek physician Hippocrates of Kos (c.460–c.370 BC), often referred to as "The Father of Medicine;" engraving by Peter Paul Rubens, 1683

Living within the "great chain of being"

In a 2005 article published in Public Health Nutrition, Geoffrey Cannon of the World Health Policy Forum writes: "From the beginnings of recorded history and in Europe up to and beyond the mediaeval era, teaching and practice on food, nutrition and health have been deep and broad. In what is now Europe, Pythagoras, Heraclitus, Alcmaeon, Hippocrates, Celsus, Dioscorides, Plotinus, Pliny the Elder, Plutarch and Porphyry, as well as other Greek, Roman and other philosophers, physicians and teachers who laid foundations for Western science and medicine, developed inductive and deductive systems of thinking about food and health between 600 BCE and 300 CE." Cannon continues: "The flowering of Arab culture between the eighth and the twelfth centuries CE included comparable teachings of Rhazes, Ibn Botlân, Ibn Sina Abu Ali Al Husain (Avicenna) and Moses Maimonides, Jewish physician to Salah al-Din (Saladin); these also became synthesised in 'The Regime of Health' treatise of the first major medical school in Europe at Salerno, published as from 1100 CE and one of the first books to be printed … The Greek term *diaita* [δίαιτα] means 'way of life' or 'way of being', and the term 'diet' was used in this sense in treatises and handbooks until recent times in Europe. Human health and welfare are seen ecologically, in the context of the whole living and physical world, the 'great chain of being.'" [3]

Cannon's words, published in 2005, are not a million miles from the EAT–Lancet Commission when it states that "The global adoption of healthy diets from sustainable food systems would safeguard our planet and improve the health of billions."[2] Have we come full circle in the past 2,000 years, pushing the planet to the edge of what it can bear, only to realize what was known scores of generations ago? And what went wrong in the interim?

Dietetic medicine

In Ancient Greek times, the link between diet in its broadest sense and health in its profoundest sense was clearly recognized. Although recent research by Diana Cardenas[4] suggests that Hippocrates' famous injunction "Let food be thy medicine and thy medicine be thy food" is in fact apocryphal, dietary intake was central to the concept of Hippocratic medicine. "The properties of foods were meticulously analyzed in the treatise On Regimen,"[5] states Cardenas: "Physicians were then able to prescribe a detailed food regimen to patients based on their individual nature, activity, age, season, etc. Thus it is considered that medicine in the Hippocratic era was in fact mainly a dietetic medicine, not a pharmacological or surgical medicine." This sounds preciously close to a cross between today's concepts of personalized nutrition and personalized health – and even more so when Hippocrates observes that "Eating alone will not keep a man well; he must also take exercise. For food and exercise, while possessing opposite qualities, yet work together to produce health." [6]

The ruins of the monastery of Disibodenberg in Rhineland-Palatinate, Germany, where Hildegard von Bingen lived and worked for 39 years

> "Ancient Greek physicians were able to prescribe a detailed food regimen to patients based on their individual nature"

A similarly holistic view of the relationship between diet and health was expressed by the Benedictine abbess and polymath Hildegard von Bingen, who lived in Germany from 1098 to 1179, and is today widely considered as the founder of scientific natural history in Germany and the country's first nutritional theorist. While not all contemporary physicians or dieticians would agree with some of the detail of Hildegard's teachings, there is a strong revival of interest in her thinking today, especially in the German-speaking world. Her emphasis on balance and moderation strikes a contemporary chord, and few nutritionists today would argue with her insistence on the importance of whole grains, fruits and vegetables in the diet, the value of cooking foods carefully so as to preserve their nutritional content, and the vital role of gut health, as well as of emotional wellbeing.[7] "When the body and the soul function in excellent harmony," she wrote, "they receive the supreme recompense of joy and health."[8]

"The laboratory of the household"

Although the country is not famed for its culinary traditions, Britain in the 19th century produced one of the first great modern cooking writers, in the form of Isabella Beeton (1836–65), better known as Mrs Beeton. Although her primary focus was domestic science rather than nutrition, her first book, *Mrs Beeton's Book*

Isabella Beeton, née Mayson (1836–65), photographed in about 1854

of Household Management, makes a link between food preparation and physical and mental wellbeing that fits well with today's discourse of food systems, food environments and food choices: "The kitchen is the great laboratory of the household, and much of the 'weal and woe' as far as regards bodily health, depends on the nature of the preparations concocted within its walls."[9] Mrs Beeton also appears to have a completely contemporary understanding of the importance of avoiding food waste when she writes: "Frugality and economy are virtues without which no household can prosper. The necessity of economy should be evident to every one, whether in possession of an income barely sufficient for a family's requirements, or of a large fortune which seems to put financial adversity out of the question. We must always remember that to manage well on a small income is highly creditable … Economy and frugality must never, however, be allowed to degenerate into meanness."[10]

If Mrs Beeton's expressed care for bodily health may make her seem at least a distant cousin of Hildegard von Bingen, a telltale choice of word places her firmly in the modern era, however. It is the word 'laboratory' – a word that would have had a very modern ring to the Victorians, who (despite our notions to the contrary) loved to think of themselves as being ultramodern. It is a word intimately associated with notions of science, technology and progress. And it was precisely during Mrs Beeton's career as a cookery author that – if we are to accept the analysis of Geoffrey Cannon – the holistic relationship between food and health was challenged in ways that were to have unexpected and deleterious effects.

The human machine and the machine of state

"In post-mediaeval and Renaissance Europe," writes Cannon, speaking of the century from 1850 to 1950, "and then in the USA and other technologically developing countries, human beings and all other living things became identified as marvellous machines, by analogy with clocks, pumps, trains, or other forms of engineering. Study of life itself, and of consciousness and vitality, became seen as metaphysical. Aspects of humanity other than the physical were excluded by the rising sciences, within the context of a dominant ideology based on principles of political and economic power and growth."[3] (This development is analogous to the trend in our own times to compare human beings with computers – 'hardwired' to behave in this way or that but lacking 'the bandwidth' to take in excessive quantities of information.) "The science of nutrition in its first period, roughly between 1850 and 1950," continues Cannon, "was harnessed by governments of the great European powers and the USA to increase the yield of food from plants and animals, and to build up their human resources, when more and more factory workers and foot soldiers were needed to increase national advantage and to service industrialisation and imperialism. In the most powerful European countries, philanthropists and politicians were united in their interest in nutrition. Both were preoccupied with the condition of the poor, partly for fear of uprisings of enraged ideologues and under-classes." He concludes: "The overall objectives of successive governments were internal social security, competitive advantage over other industrialised nations, and world domination. Consequent food and nutrition policies included legal, fiscal, regulatory and other methods affecting price, availability and quality. They worked."

> "The science of nutrition between 1850 and 1950 was harnessed by the great European powers and the USA to increase the yield of food, and to build up their human resources"

A problem solved

And then, in Cannon's view, "the genie of nutrition was put back into the bottle."[3] He attributes this to a number of factors. The first – and perhaps, from today's perspective, the most surprising – was the view that everything that there was to discover about nutrition had been discovered. Writing in the late 1930s, the leading British nutritionist Sir Jack Drummond stated that "There is no problem of nutrition in Britain today. … The position is perfectly clear-cut."[11] The experience of the Second World War – in which Drummond masterminded

the rationing policy that kept Britain from starvation – served only to intensify this view. Nutrition was understood; what was difficult was to supply it in sufficient quantities to those who needed it. Cannon goes on to list another four main reasons for the decline in nutritional science between 1950 and 2000: oligarchy (maintenance of government control, international agency unaccountability), cacophony (unexplained policy U-turns, marketing and advertising babble), technology (accelerating specialism, corralling of science) and ideology (let the consumer beware, Band Aid).

Diets for a complex world

Whether or not one agrees with the detail of Cannon's analysis, it is hard not to conclude that the position today is anything but clear cut. The rapid advances in genomics, nutrition science and technology made during the past two decades are offering deep insights into the relationship between diet and noncommunicable diseases in particular; hidden hunger, diabesity and the double burden of malnutrition have become key terms in the discourse of nutrition; and food systems are perceived as having an importance, and also a complexity, that was underestimated until relatively recently. The problems appear to grow all around us, even as the potential solutions to them multiply. Perhaps it is no surprise that the West has spawned so many new diets in the past few decades, from the Atkins Diet through the Dukan and the Paleo Diets to the Weight Watchers Diet. With their emphasis on the exclusion of certain foods and behaviors and their primary focus on weight loss, many diets in the modern sense have the attraction of offering a degree of simplification and the promise of purity in a complex, fast-moving and over-busy world. Others, however – most notably the Mediterranean Diet[12] first identified by the American nutritionist Ancel Keys in the 1950s, and its much younger cousin the Nordic Diet[13] – do deliver scientifically proven health benefits through reducing the risk of metabolic syndrome and noncommunicable diseases such as cancer and cardiovascular disease.

Most modern diets are not, however, diets in the sense that Hippocrates would have understood the term. Nor are they diets in the sense proposed by the EAT–Lancet Commission. Writing in Vol. 30(2) 2016 of this magazine, Klaus Kraemer observed: "I do not think that a discussion that focuses on diet alone, or one that fails to recognize that food and nutrition security encompasses far more than just the regular consumption of food and drink, genuinely helps us address the complex challenges of malnutrition in all its forms across the world."[14]

Nutrition is about much more than biochemistry and energy balance – and even as our scientific understanding of biochemical processes in the body reaches new levels of sophistication in the age of omics, this becomes ever more apparent. Perhaps what the world needs at this juncture is a reappropriation of the Ancient Greek concept of *diata* in its widest sense, an understanding that is both physical and metaphysical, and an exploration of new ways of being in which the simple mystery of food plays a central part.

Many modern diets focus primarily on weight loss and are not a regimen for living in the Ancient Greek sense

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Field Reports

Nutrient Density as a Dimension of Dietary Quality

Part II: Harmonization of the investigational protocol in a multicenter evaluation

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Key messages

- The concepts and calculations of 'nutrient density' and 'critical nutrient density' provide valuable tools for identifying, evaluating and resolving problems of micronutrient inadequacy.
- When micronutrient intakes are low because energy intake is low, consumption of usual foods in higher amounts may restore adequacy; but without energy deficit, micronutrient gaps require greater consumption of nutrient-rich or enriched foods.
- In the midst of a worldwide obesity epidemic, the dietary energy requirements and intakes associated with 'normal' and 'excessive' weight status interact with micronutrient considerations.
- This multicenter evaluation will serve to illustrate the principles of nutrient density across diverse populations. It was designed to recruit a target population with similar nutrient requirements (i.e., nonpregnant, nonlactating women of reproductive age), but varying energy requirements (i.e., normal weight women versus obese women).

Background and context

This paper is part two of our 'Density as a Dimension of Dietary Quality' series published in *Sight and Life* magazine.[1] We describe here the harmonization of an investigational protocol in a multicenter evaluation to illustrate the principles of nutrient density across diverse populations.

The double burden of malnutrition

Many people in deprived settings consume a monotonous diet based on nutrient-poor starchy staples, which may have sufficient calories but do not provide the micronutrients needed for good health.[2–4] As a consequence of a global food supply that maximizes inexpensive calories from staple grains, vegetable oils and sugar crops[5] and energy-dense processed foods,[6–9] people around the globe suffer from the double burden of malnutrition, which is characterized by the coexistence of undernutrition with overweight and obesity, or with nutrition-related noncommunicable disease, throughout the life course.[10,11] The double burden of nutritional disease adds an additional layer of complexity but raises the possibility that double-duty actions could simultaneously reduce obesity and undernutrition.[12–14]

Shifting from energy-dense to nutrient-dense diets

Increasing the nutrient content of the diet, while maintaining an adequate and appropriate energy content, is critical for wellbeing along the life course as well as for the prevention of overweight and obesity.[15] It has been demonstrated that consuming nutrient-dense foods – such as green leafy vegetables, eggs and nuts – is associated with a modestly lower risk of cardiovascular disease, diabetes and all-cause mortality.[16] Shifting diets from energy-dense to nutrient-dense will have a significant beneficial effect on the risk of developing noncommunicable diseases along the life course, helping to keep a high life expectancy and quality of life.

> "Shifting diets from energy-dense to nutrient-dense will have a significant beneficial effect on the risk of developing noncommunicable diseases along the life course"

Nutrient density as a dimension of dietary quality

The nutrient adequacy of a diet is typically assessed by comparing nutrient intakes with nutrient requirements, such as the 2004 Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) Recommended Nutrient Intakes (RNI).[17] However, these measures do not account for total energy consumed. Nutrient density (defined in **Box 1**) brings energy into the equation. Our companion paper, entitled 'Nutrient Density as a Dimension of Dietary Quality. Part I: Theoretical considerations of the nutrient-density approach in a multicenter evaluation' sets out the principles of the nutrient-density approach.[1]

BOX 1: Definition of nutrient density

Nutrient density is the ratio of the amount of a nutrient in the diet to the energy provided by the same diet. It is frequently expressed as the amount of the nutrient per 1,000 kcal or MJ of energy.

The nutrient density of the observed diet refers to the ratio of estimated nutrient intakes to estimated energy intake (for example, assessed by means of 24-hour dietary recalls). The *'critical nutrient density'*, by contrast, is a reference value that consists of a recommended daily intake for a specific nutrient as the numerator and daily energy requirements as the denominator (**Box 2**). It is the amount of nutrients, typically per 1,000 kcal, that would achieve the nutrient requirements. In other words, when a diet is constituted with at least the critical nutrient density, one is assured that the requisite amount of a nutrient of interest will be consumed when energy needs are met.

BOX 2: Calculations to compute the observed and critical nutrient densities

$$\textbf{Observed nutrient density} = \frac{\text{Observed nutrient density}}{\text{observed energy intake (kcal)}} \times 1{,}000$$

$$\textbf{Critical nutrient density} = \frac{\text{daily nutrient requirement (units)}}{\text{daily energy requirement (kcal)}} \times 1{,}000$$

The nutrient-density approach has shown itself to be a valuable tool for nutrition education, dietary guidance and meal planning.[18,19] Almost half a century ago, the FAO and WHO proposed the use of nutrient densities as a means to account for known differences in the energy and nutrient requirements of specific population subgroups.[20] Two decades ago, a consultancy to the FAO suggested replacing the traditional measures of diet quality with the nutrient-density approach.[21] The nutrient-density concept was applied to the development of food-based dietary guidelines in which foods that made a greater contribution to nutrient intakes were prioritized over meeting total energy needs.[21]

TABLE 1: Critical nutrient density for a 'normal' weight woman versus an 'obese' woman*

	Recommended nutrient intakes (RNI),** unit/day	Critical nutrient density, unit/1,000 kcal	
		Woman with a daily energy requirement of 1,850 kcal***	Woman with a daily energy requirement of 2,250 kcal****
Folate DFE (µg DFE)	400.0	216.2	177.8
Pantothenate (mg)	5.0	2.7	2.2
Thiamine (mg)	1.1	0.6	0.5
Riboflavin (mg)	1.1	0.6	0.5
Niacin (mg NE)	14.0	7.6	6.2
Vitamin B_6 (mg)	1.3	0.7	0.6
Vitamin B_{12} (µg)	2.4	1.3	1.1
Biotin (µg)	30.0	16.2	13.3
Vitamin C (mg)	45.0	24.3	20.0
Vitamin A (µg RE)	500.0	270.3	222.2
Vitamin D (µg)	5.0	2.7	2.2
Vitamin E (mg α-TE)	7.5	4.1	3.3
Vitamin K (µg)	55.0	29.7	24.4
Calcium (mg)	1,000.0	540.5	444.4
Iron (mg)			
15% bioavailability	19.6	10.6	8.7
10% bioavailability	29.4	15.9	13.1
Magnesium (mg)	220.0	118.9	97.8
Selenium (µg)	26.0	14.1	11.6
Zinc (mg)			
Medium bioavailability	4.9	2.7	2.2
Low bioavailability	9.8	5.3	4.4
Iodine (µg)	150.0	81.1	66.7

DFE = dietary folate equivalent, **NE** = niacin equivalents, **RE** = retinol equivalents, **TE** = tocopherol equivalents

* Normal weight is defined as body mass index (BMI) of 18.5–25 kg/m² and obese is defined as BMI > 30 kg/m²

** Recommended Nutrient Intakes for women

*** Energy requirement for a woman aged 30–59.9 years, with a mean weight of 55 kg and a sedentary lifestyle; assuming a height of 158 cm, her BMI would be 22.0 kg/m², which is classified as 'normal'

**** Energy requirement for a woman aged 30–59.9 years, with a mean weight of 85 kg and a sedentary lifestyle; assuming a height of 158 cm, her BMI would be 34.0 kg/m², which is classified as 'obese'

> "Designing food patterns that are simultaneously nutrient-rich, low-cost, culturally acceptable and environmentally friendly is challenging"

Challenges of nutrient-dense diets

Translating the concept of nutrient density into healthier everyday diets requires the combination of nutrient-profiling methods with other strategies for improving food habits and health. Designing food patterns that are simultaneously nutrient-rich, low-cost, culturally acceptable and environmentally friendly is challenging.[22] Several studies have shown that 'empty' calories tend to be cheap, whereas diets that include more nutrient-rich foods are generally more expensive.[9,23–25]

Investigational protocol in a multicenter evaluation

A multinational survey protocol is currently being implemented in three diverse regions with funding from *Sight and Life* to fur-

ther explore the applications of the nutrient-density and critical-nutrient-density approaches in public health epidemiology.

The aim of the investigation is to assess the dietary adequacy of the diet of normal weight (body mass index [BMI] of 18.5–25 kg/m²) and obese (BMI > 30 kg/m²) women in each country setting and to compare diets between these two target groups within each country setting. Dietary adequacy will be assessed both in absolute terms (i.e., estimated intakes) and using the nutrient-density approach (i.e., nutrient in relation to calorie intake).

Each individual has a unique energy requirement based on body size, lean body tissue and exertional efforts; however, recommended intakes for micronutrients are common for any given age, sex or physiological group independent of the weight of the individuals. As such, obese women will have greater energy requirements and, therefore, higher energy intakes than normal weight women, but their micronutrient requirements will be the same. As a consequence, the diets of obese women will have lower critical nutrient densities than those of normal weight women (**Table 1**). However, even with a greater 'allowance' for intake, we hypothesize that 'problem nutrients' (i.e., nutrients consumed in insufficient amounts and qualified as below adequacy based on critical nutrient density) are likely to remain.

Characteristics of the survey sites in Asia, Africa and North America

Three distinct survey sites across three continents were chosen; these include Indonesia in Asia, Mexico in North America and South Africa in Africa (see **Figure 1**).

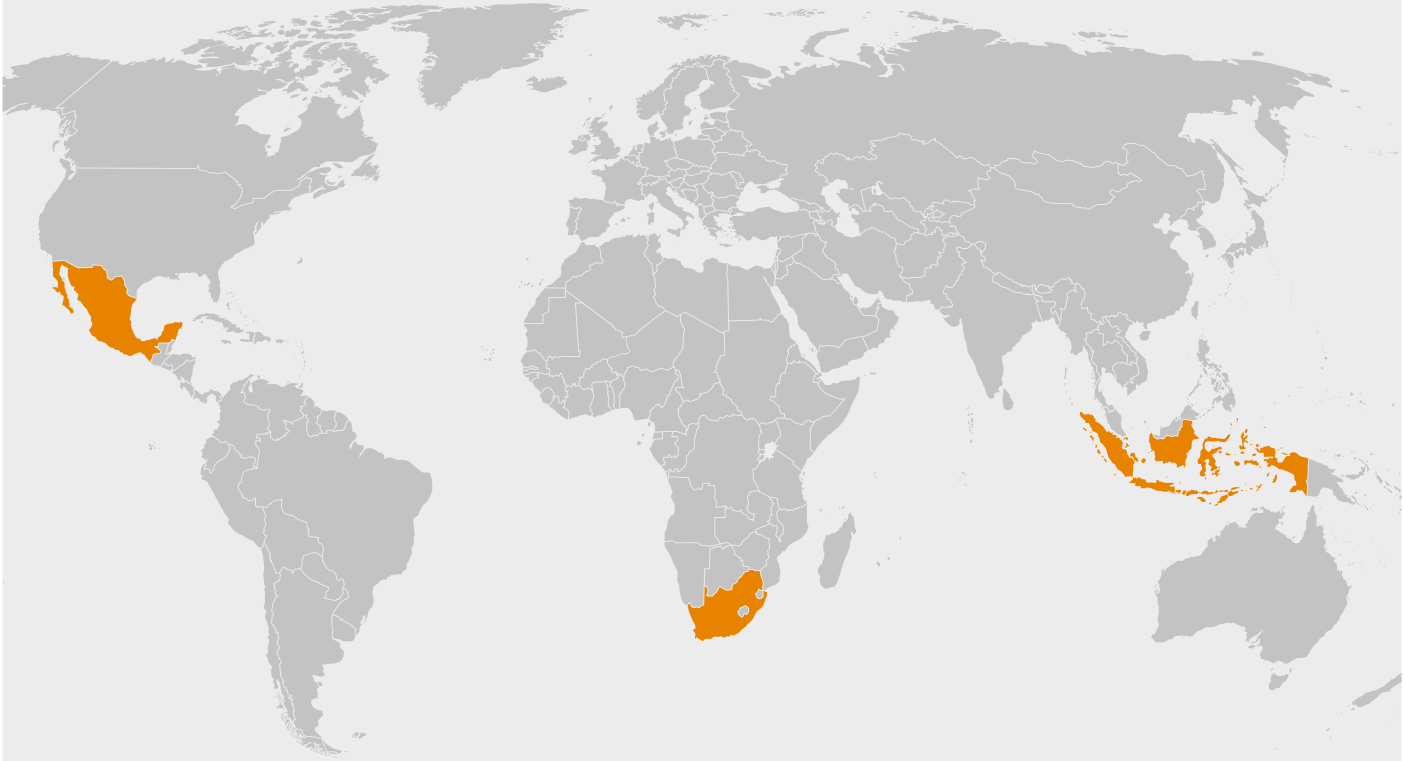
Existing data meeting set criteria were available for South Africa, therefore no additional fieldwork was undertaken. Data collected for a study that aimed to assess the vitamin A and anthropometric status of South African preschool children and their mothers from four areas with known distinct eating patterns were identified as suitable for the aims of the current survey. Data were collected between June and November 2011, and findings for preschool children were published in 2015.[26] In Mexico and Indonesia, data were collected prospectively primarily for this analysis.

In **Boxes 3–6**, we describe the survey areas and dietary habits and patterns of these countries' populations.

Survey design

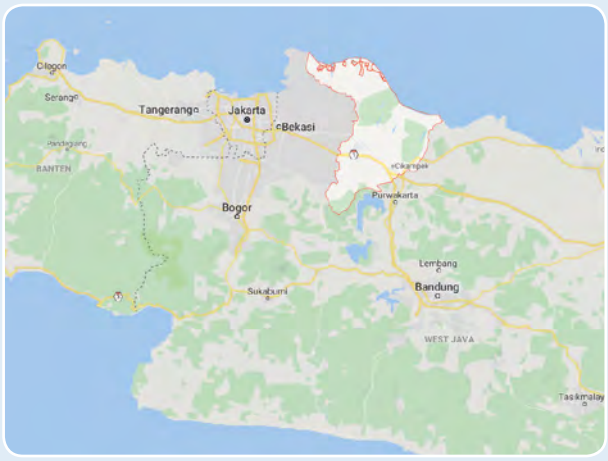
The survey design is a cross-sectional, observational survey among convenience samples of women in low-income, urban settings across three countries. In each country setting (n=3), ~40–50 normal weight women (defined as BMI 18.5–25 kg/m²) and ~40–50 obese women (defined as BMI > 30 kg/m²) were

FIGURE 1: Countries of interest include Indonesia in Asia, Mexico in North America and South Africa in Africa



BOX 3: Description of the survey areas and dietary patterns in Indonesia

KARAWANG DISTRICT, WEST JAVA PROVINCE, INDONESIA



Description of the survey site in Western Java

Karawang Regency in the West Java province is located 32 miles east of Jakarta (6.3227° S, 107.3376° E). It is a peri-urban area, where industrial and agricultural areas coexist and communities have a high marginalization index. It has the altitude of 0–1,279 m above sea level.

As at the latest census (2015), the province was estimated to have a population of 1,166,478 inhabitants, and a population density of 1,297 persons/km². The majority of the population (~60%) only has elementary school education, and very few (3.5%) have university education. Early marriage was relatively high in Karawang.[27]

The main economic activities include trade and hospitality industry (31%), processing technology (22%) and agriculture (18%). Paddy is the main produce of Karawang. The other produce includes soybean, corn and some vegetables. As Karawang has coastal areas, fisheries play an important role for economic development. As of 2017, the output of fish was 43,700 tons; the majority came from cultured fresh-water fish and sea fish.[28]

Malnutrition is prevalent: among children < 5 years old, 34.9% are stunted, 19.4% are wasted and 14% are overweight. Among women > 18 years old, 8.8% are underweight and 21.9% are overweight (BMI > 27 kg/m²). Among women of reproductive age, 21.5% have short stature (height < 150 cm).[29]

Urban consumption patterns in Western Java

The principal staple in the region is rice. Other carbohydrate sources include noodles and wheat flour (fortified with thiamin, riboflavin, folic acid, iron and zinc). Eggs, tofu, tempeh, chicken and fresh-water fish are common side dishes. Vegetables commonly consumed include leafy vegetables either consumed as stir-fried, soup or sour soup, or raw with chili sauce (*sambal*). Dairy products are rarely consumed. Oil is widely used for food preparation.[30]

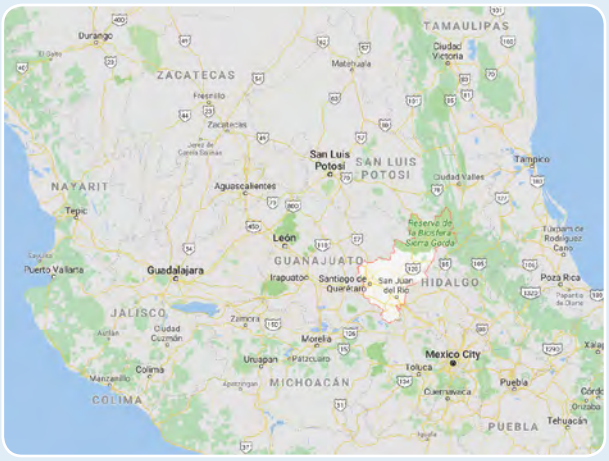
The diets are characterized by an increase in the consumption of ready-to-eat foods and snacks bought outside the home from food stalls or food shops (*warung*).[30]

Data collection at the Posyandu Sub-Hamlet 3 Perumnas, Karawang, West Java, Indonesia, in October 2018: measurement of a participant's body weight using a Tanita digital scale

An enumerator conducts an interview to capture the dietary intake (24-hour food recall) of a participant in At-Taubah School, Karawang, West Java, Indonesia, in October 2018

BOX 4: Description of the survey areas and dietary patterns in Mexico

STATE OF QUERÉTARO, MEXICO



Description of the survey site in North-Central Mexico

The site of interest in Mexico is the city of Santiago de Querétaro in the state of Querétaro, located 200 km north of Mexico City in the central region of Bajío (20°35'17" N and 100°23'17" W). Santiago de Querétaro is ~1,800 m above sea level with ecosystems varying from deserts to tropical rainforest. Although Querétaro state is small, it hosts a population of over 2 million, concentrated in only one urban center and some smaller communities. Ethnicities include Zapoteca-speaking Otomí, Pame, Jonace and Ximpece indigenous inhabitants, along with Spanish-speaking mixed and European Ladinos. The former are dominant in the countryside, where traditional dresses can still be seen, whereas the latter predominate in the urban capital.

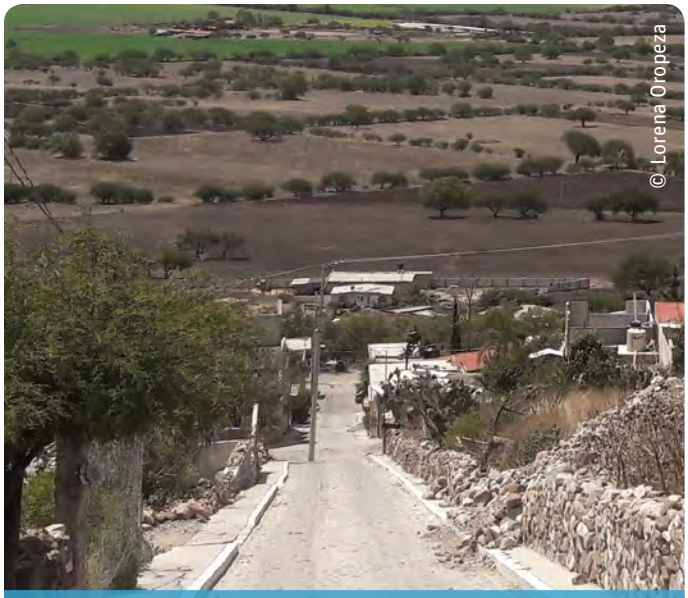
The state of Querétaro is now considered to have the fifth largest economy in the country, and the four strategic industries are food and beverages, automotive, aerospace and home appliances. Living standards are higher than average for Mexico in and around the city of Querétaro, but diminish significantly in the rural areas.

At the state level, the combined prevalence of overweight and obesity of adult women is 65.8%, and less than 2% of the population are undernourished (BMI < 18.5 kg/m²). Less than 10% of the adult population in Queretaro suffer from anemia (7.8% in rural and 7.3% in urban areas).[31]

Urban consumption patterns in North-Central Mexico

The typical diet includes animal-source products such as pork (*carnitas*), chicken, beef and lamb (*barbacoa*). The main staple of the region is maize in the form of tortilla, made out of lime-treated maize (overnight or partially treated), and other forms include *tamales*, *guaraches* and *gorditas*. The garnishes consumed in the region are rice, beans, potatoes, cactus (*nopales*), and cooked vegetables. The traditional beverages include honey water, *atole* and *charape* (made out of *pulque* and peanuts).

In Mexico, there are national fortification programs, such as the fortification of maize and wheat flour with iron, zinc and folic acid. Also, milk has to be fortified with vitamins A and D, and salt with iodine. Commercial products (for example, ready-to-eat cereals, cookies and beverages) are also fortified with a wide variety of micronutrients.



Main road to the community of Tierra Blanca, Querétaro, Mexico

Diet evaluation using 24-hour recall in the community of Rancho Largo, Querétaro, Mexico

BOX 5: Description of the survey areas and dietary patterns in South Africa

CAPE TOWN IN THE WESTERN CAPE PROVINCE

Description of the survey site in Western Cape, South Africa

For the South African site, secondary data collected in 2011 was used. Study participants resided in Ocean View, a small, densely populated urban township on the southern peninsula of Cape Town in the Western Cape Province. Ocean View lies at 34°9'12" S and 18°21'19" E. The majority of the population is colored, and most people speak either Afrikaans or English.

According to the 2016 South African Demographic and Health Survey, the provincial combined prevalence of overweight and obesity (BMI ≥ 25 kg/m²) of women is 73.3%. A very high proportion (63.7%) of women are prediabetic (glycated hemoglobin level [HbA1c] between 5.7% and 6.4%), 12.2% are diabetic [HbA1c ≥ 6.5%] and 23.9% are anemic. Among children under 5, 22.9% are stunted.[32]

Urban consumption patterns in Western Cape, South Africa

In South Africa, the two most frequently consumed staple foods, maize meal and wheat flour bread, have by legislation been fortified with a premix of eight key micronutrients since 2003. Salt iodization is mandatory. Whereas maize is the most frequently consumed food in South Africa, in the Western Cape Province, maize is only the tenth most frequently consumed food. In terms of starchy foods, rice, potato and bread, respectively, are consumed more frequently than maize.[33] Low dietary diversity was reported for 28.2% of adults in the province, compared with the national figure of 39.7%.[34]

included in the survey, bringing the total sample size to ~240–300 women.

Survey locations and collaborators were chosen because the lead investigator has significant experience in dietary research, including the collection of 24-hour dietary recall and dietary data analysis.

Inclusion and exclusion criteria

In the interests of having a somewhat homologous population sample with comparable nutrient requirements, only nonpregnant and nonlactating women aged 18–39 and living in poor, urban or semi-urban communities were included in the survey. To allow comparison of the diets of women with different energy requirements, only normal weight women (BMI of 18.5–25 kg/m²) or obese women (BMI > 30 kg/m²) were included.

Criteria for inclusion included willingness to participate in the survey and the ability to speak the main local language (*Bahasa* in Indonesia, Spanish in Mexico, and Afrikaans or English in South Africa). Criteria for exclusion included migrants, as well as individuals suffering from cardiovascular, respiratory, endocrine, blood system, gastrointestinal tract or other systemic diseases.

Independent ethical approval was sought in each country setting.

Survey tools

24-hour dietary recalls

Dietary intake data was collected by means of a quantitative 24-hour dietary recall. To minimize errors and biases, an interactive, systematic multi-pass method was used, which had been specifically developed for use in low-income countries with low rates of literacy.[35] The multi-pass probing methodology was applied to minimize underreporting, especially among obese women.[36,37] Recipes were recorded, including all ingredients and their respective portion sizes in household measures. Food serving sizes were determined using predetermined props such as household measure models and life-sized photo-models.

The 24-hour dietary recall method has been validated in several settings, but the actual interview procedures of the multi-pass methods can be adapted to the local context without compromising validity.[38]

Sociodemographic characteristics

Basic sociodemographic characteristics of the women were collected, including age, marital status, formal education and current occupation. The same response categories were used in each setting, with some exceptions.

In addition, 10 country-specific questions about household characteristics and asset ownership were assessed to derive a Poverty Probability Index (PPI) score.[39] In South Africa, the

variables needed to compute a PPI score were not collected. However, some household characteristics that are homologous with subcomponents of the PPI index were collected in the survey (i.e., source of drinking water, toilet facilities, electricity in-house, energy source mostly used for cooking food and household sources of income).

Physical activity

The short version of the International Physical Activity Questionnaire (IPAQ) was administered in Mexico and Indonesia.[40] This tool was previously validated in different contexts.[41] The IPAQ assesses time spent in the previous seven days on vigorous, moderate, walking and sitting activities. Physical activity levels (PAL) – classified as sedentary or light activity lifestyle (PAL score 1.40–1.69), active or moderately active lifestyle (PAL score 1.70–1.99), or vigorous or vigorously active lifestyle (PAL score 2.00–2.40) – are needed to compute energy requirements. In South Africa, no data on physical activity was collected, and assumptions will be made about activity level based on occupation.

Anthropometry

Height (to the nearest 0.5 cm) and weight (to the nearest 100 g) measurements were collected in duplicate following standard procedures.

Postdata collection counseling of participants

At the end of the data collection phase, all participants in Mexico and Indonesia were counseled on healthy eating and lifestyle practices by trained nutritionists.

Data collection procedures

Training of enumerators

In each setting, enumerators were trained with emphasis on probing techniques to minimize underreporting and overreporting of foods and beverages.

Testing of survey tools

At each survey site, the survey tools were tested with a similar population and adapted according to feedback. Translations were verified through back translations and group discussions to ensure that the meanings of the questions were retained.

Recruitment of respondents

In Indonesia, participants were recruited from community centers, mainly from local health posts (*Posyandu*) and from village lists. In Mexico, participants visiting the health clinics and community centers at the four communities were invited to participate in the survey. Most women in these communities meet once a month at these locations as part of the activities related to a national health program called *'Prospera'*. This is a cash-transfer program whereby women are asked to attend their clinics and the meetings at least once a month in order to receive the economic bonus. In South Africa, participants were recruited through house-to-house visits. A map of the area was used to divide the area into five sections; 40 survey participants were randomly recruited per section. All measurements were taken at a central location within the survey area. For the purpose of the current study, a subsample of 50 normal weight (defined as BMI 18.5–25 kg/m²) and 50 obese (defined as BMI > 30 kg/m²) women meeting the selection criteria were randomly selected.

Data collection procedures in the field

Data were collected by trained enumerators by means of face-to-face interviews in the local language using structured survey tools on paper. In Indonesia and Mexico, women were initially screened for BMI, and only women meeting the selection criteria were invited to complete a 24-hour dietary recall interview.

Data processing

Data were entered into an Excel template specifically designed for the project (single entry). A coding scheme was available. Data were cleaned for outliers using standardized procedures. Women with estimated energy intakes < 0.9 or > 3.0 times the basal metabolic rate were excluded.

Dietary data processing involves:

1. the conversion of food and beverages reported in household measures to amounts consumed in grams;
2. the disaggregation of recipes into individual ingredients with the amount of each ingredient consumed in grams; and
3. linking estimated intakes in grams to local food composition tables.

The software used for dietary processing varied by country, and these were chosen according to previous experience. Indonesia used NutriSurvey, Mexico used data entry templates in Excel, and in South Africa the SAS software package (version 9.1; SAS Institute Inc., Cary, NC, USA) was used. The food composition databases used were: the 2013 SMILING food composition table for Indonesia;[42] the United States Department of Agriculture (USDA) National Nutrient Database,[43] and the National Institute of Medical Sciences and Nutrition 'Salvador Zubirán' 2014 *'Tablas de uso practico de los alimentos de mayor consumo'* in Mexico;[44] and the South African Food Composition Database (SAFOODS) in South Africa.[45]

The output of the dietary data processing will include:

1. individual daily estimated intakes of energy, protein and key micronutrients;

2. dietary sources of protein and key micronutrients; and
3. dietary diversity scores and the proportion of women meeting the Minimum Dietary Diversity for Women (MDD-W).[46]

Energy and nutrient requirements

Energy requirements will be computed as described in the FAO/WHO/UN Human Energy Requirements report using measured body weight, basic metabolic rate (BMR) and the PAL categories described above.[47] Tables with calculations for women aged 18–29.9 and 30–59.9 years will be used.

Protein requirements will be calculated assuming a daily requirement of 1.3 g/kg.[48]

The 2004 WHO/FAO Recommended Nutrient Intakes (RNI)[17] and the derived Estimated Average Requirements (EAR)[49] will be used as reference values for requirements. These requirements are uniform for females aged 19–50 (premenopausal), regardless of body weight. Both high and low bioavailabilities of the diet will be assumed for zinc requirements; and either 15% or 5% bioavailability for iron requirements. Key micronutrients (vitamin A, thiamine, riboflavin, niacin, folate, vitamin C, calcium, zinc and iron) will be included in the analysis.

Expected outputs

This analysis will be led by Marieke Vossenaar, following a common methodology across all three settings. Data will be analyzed using SPSS for Windows 22.0 (SPSS Inc., Chicago, IL, USA).

Nutrient adequacy using absolute gaps

The cut-point method (% of EAR) will be used to compute the probability of nutrient adequacy for key nutrients. This is a method of assessing the nutrient adequacy of groups. It consists of assessing the proportion of individuals in the group whose usual nutrient intakes are below the EAR. The nutrient gaps will be computed as the difference between requirements and the estimated amounts in the diet using RNI and EAR values.

Furthermore, dietary diversity and the proportion of women meeting MDD-W will be explored in relation to nutrient density.

Nutrient-density analysis

We shall put into practice the concept of 'critical nutrient density'; the expected outcomes are listed in **Box 6**. Comparisons will be made between normal weight and obese women within each country.

If there is an apparent energy deficit, we shall identify those nutrient requirements that would be met by more of the same foods (i.e., existing diet) and those nutrient deficits that would require dietary modifications (i.e., more nutrient-dense dietary sources).

BOX 6: Expected outcomes of the nutrient-density analysis

- Median **estimated nutrient density** for key micronutrients
- **Critical nutrient density** for key micronutrients
- **Observed nutrient density** in relation to **critical nutrient density** – gap and percentage of critical nutrient met
- **Problem nutrients** – below adequacy based on critical nutrient density.

If there is no energy deficit, we shall identify those nutrient deficits that require dietary modifications (i.e., more nutrient-dense dietary sources).

> "This work will provide an opportunity to develop a rigorous approach towards nutrient-density analysis"

Conclusions

The nutrient-density principle ensures that nutrients are provided in sufficient concentrations in the diet to satisfy individuals' nutrient needs if they consume sufficient food to maintain energy balance.

In this protocol, survey procedures were standardized across countries; however, cross-country comparisons will be limited because of the lack of representativeness of the samples. Nevertheless, within each setting, with unique cuisines and dietary habits, similar contrasts between normal weight and obese women will be explored.

This work will provide an opportunity to develop a rigorous approach towards nutrient-density analysis, allowing the assessment of specific nutrient inadequacies in various settings to provide valuable information for efforts to tackle deficiencies (such as fortification).

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Prioritizing Adolescent Health

Why India needs a healthy eating and living index

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Key messages

- Adolescents comprise the largest population of the world today, especially in developing countries. Around 21 percent of the Indian population comprises adolescents.
- As habits formed during adolescence get carried into adulthood, it is important to enforce healthy lifestyles right from a young age to ensure greater productivity among the future nation builders. Adolescence is a complex transitional phase during which a human being evolves into an adult, with various physical, psychological, sexual and neuro-development changes constantly taking place.
- Indian adolescents face a triple burden of malnutrition due to factors such as the nutrition transition, the increased demands of growth and development, and compromised diets for both macro- and micronutrients.
- There is a need to develop an 'easy-to-use' scale that measures overall diet quality and factors in physical activity, stress and sleep among adolescents to predict their wellbeing.

Background and context

Nutrition is crucial during all stages of the life cycle, especially the adolescent phase, as it is a milestone in the growth and development of an individual. Good dietary habits and healthy lifestyles in adolescence serve as a foundation for wellbeing in adulthood.

The health and nutritional status of adolescents hold prominence as they affect their productivity as well as their skills as innovators, builders and influential leaders of the future. Considering the increased demands of growth and development during adolescence, even slightly compromised diets can lead to macro- and micronutrient deficiencies. In addition, compromised lifestyles and faulty eating habits also lead to the problems of overweight/obesity and associated noncommunicable diseases (NCDs).

Adolescents in India comprise 20.9 percent of the country's population.[1] Investing in this segment of the population is the best way to power the nation's competitive advantage – its demographic dividend.[2] A vast majority of the world's adolescents – 88 percent – live in developing countries. A WHO report on the improvement of the nutritional status of adolescents recommends that measures be taken for a holistic approach toward improving the nutritional status of adolescents.[3] Although a large number of national-level programs are being implemented by the Government in India, the nutritional status of adolescents still remains a matter that needs attention.

> "Investing in India's adolescents is the best way to leverage the nation's demographic dividend"

Studies have shown that the diets of Indian adolescents are deficient in nutrients, and that most of them far from meet the recommended dietary allowances (RDAs).[4] Various studies show an alarming status of dietary deficiencies among adolescents, especially for micronutrients such as vitamin A,[5] vitamin C, riboflavin, iron, calcium and – especially among adolescent girls – magnesium.[6–8]

India faces the paradox of being one of the fastest-growing economies of the world and going through a vast sociocultural transition while at the same time being a land plagued by the triple burden of malnutrition, represented by undernutrition, overweight and obesity, and micronutrient deficiencies.

Popular foods that are high in fat, salt and sugar (HFSS) in India

© Mekha Prabhu, Ms Krantika Appugol, Ms Nisha Kothari and Ms Radhika Hedaoo, Symbiosis School of Biological Sciences, Pune, India

The nutrition transition has impacted India through the spread of foods that are high in fat, salt and sugar (HFSS). These have become an integral part of Indian diets, as they are elsewhere in the world.[9] Therefore, there is a need to constantly monitor the food, consumption, diets and lifestyles of adolescents in India in order to be able to propose viable corrective measures.

It is known that – apart from the availability of food and access to food – the eating patterns and behaviors of adolescents are influenced by a host of other factors, including peer influence, parental modeling, food preferences, cost, convenience, personal and cultural beliefs, mass media and body image.[10] There is a need to examine the health and nutritional status of adolescents through the lens of other environmental and personal factors such as stress, quality of sleep and physical activity. The data on lifestyle indicators for adolescents in India reveals sedentary lifestyles and faulty dietary habits to be the foremost factors affecting nutritional status.[11] Another major factor affecting the health and nutritional status of adolescents is physical inactivity. Research has demonstrated that almost half of youths and children in India do not meet the recommended guidelines for physical activity as given by WHO.[12,13]

"Almost half of youths and children in India do not meet WHO's guidelines for physical activity"

Stress

> Academic stress and social stress are serious risk factors affecting adolescent wellbeing. They may lead to eating disorders.

The menace of easily accessible foods that are high in fat, salt and sugar (HFSS) rule the Indian palate, especially among adolescents

Screen time

- Several studies show that lengthy TV viewing and mobile use promotes sedentary behavior among adolescents and reduces their energy expenditure.
- Targeted interventions need to be planned before screen-time addiction sets in for adolescents.

Yet another emerging factor is increasing stress – especially social stress and anxiety, which can have a negative impact on dietary behavior and body weight. Several studies in India have explored academic stress in detail.[14–17] Other studies have found academic stress is associated with a higher intake of confectionaries, candies, chocolates, flavored milk, etc.[18–20] These findings also indicate that there is a vicious and complex cycle of stress, eating and obesity. However, more evidence needs to be generated, because its progression may be instrumental in identifying successful stress-management techniques that can be used by food and nutrition practitioners to improve nutrition-related outcomes.

Moreover, inadequate sleep duration has also emerged as a potential factor predisposing adolescents to obesity.[21,22] The National Sleep Foundation Scientific Advisory Council recommends 9–11 hours of sleep for school-going children aged 6–12 years and 8–10 hours for teenagers aged 14–17 years.[23]

Another emerging factor influencing adolescent wellbeing is increasing screen time.[24] Screen time is the time spent watching television and using video game consoles, smartphones and computers. The American Association of Pediatrics (AAP) recommends at maximum 2 hours of screen time per day.[25] Currently, no Indian benchmarks exist for the various indicators mentioned above, such as physical activity, stress, sleep and

screen time, except the recommended dietary guidelines given by the Indian Council of Medical Research.

In order to examine adherence to dietary guidelines and the relationship between health and diet-related outcomes, diet quality and the effectiveness of nutrition intervention programs, some countries have developed Healthy Eating Indices (HEIs) for adolescents. Such an index was pioneered by the United States Department of Agriculture (USDA) Center for Nutrition Policy and Promotion (CNPP). This HEI reflects the dietary guidelines prescribed for Americans.[26] The HEI is revised from time to time and updated to reflect the changes in the dietary guidelines for Americans.

Indices available for Indians are sparse

In the Indian context, there are barely any such measurement attempts. Therefore, there is a need to develop and disseminate an index specific to the Indian context, which can assess nutrition, diet and other lifestyle factors governing the health and nutritional wellbeing of adolescents. Such an index will be even more reliable if it is comprehensive, factoring in lifestyle factors, stress, etc. It will certainly serve as a scoring metric that can be deployed as a community-based tool to assess the diet and lifestyle quality of adolescents and also to design nutrition communication strategies for effectively targeting the factors that promote nutrition.

Internationally, various dietary diversity measures have been used to assess the variety of foods and food groups consumed, such as the Entropy Index and Herfindahl's Index.[27] However, the dietary diversity element has not been adequately addressed either in research or in the implementation of food security policies in India.[28] The indices used determine only dietary diversity among the Indian population in the context of implementing food security interventions.

There have been scanty attempts at developing an HEI specifically for Indian adolescents. A micronutrient quality index of adolescent girls consuming lacto-vegetarian diets has been developed to measure dietary adequacy and micronutrient adequacy.[29] Correspondingly, an HEI to measure the dietary quality of adolescents has been developed.[30] However, the health spectrum must include the other health parameters, such as physical activity, stress and sleep, along with diet (**Figure 1**).

Current attempts at developing a comprehensive healthy eating and living index (CHELI) for Indian adolescents

Considering that diet and nutrition cannot be addressed in seclu-

FIGURE 1: Conceptual framework for an adolescent comprehensive healthy eating and living index (CHELI)

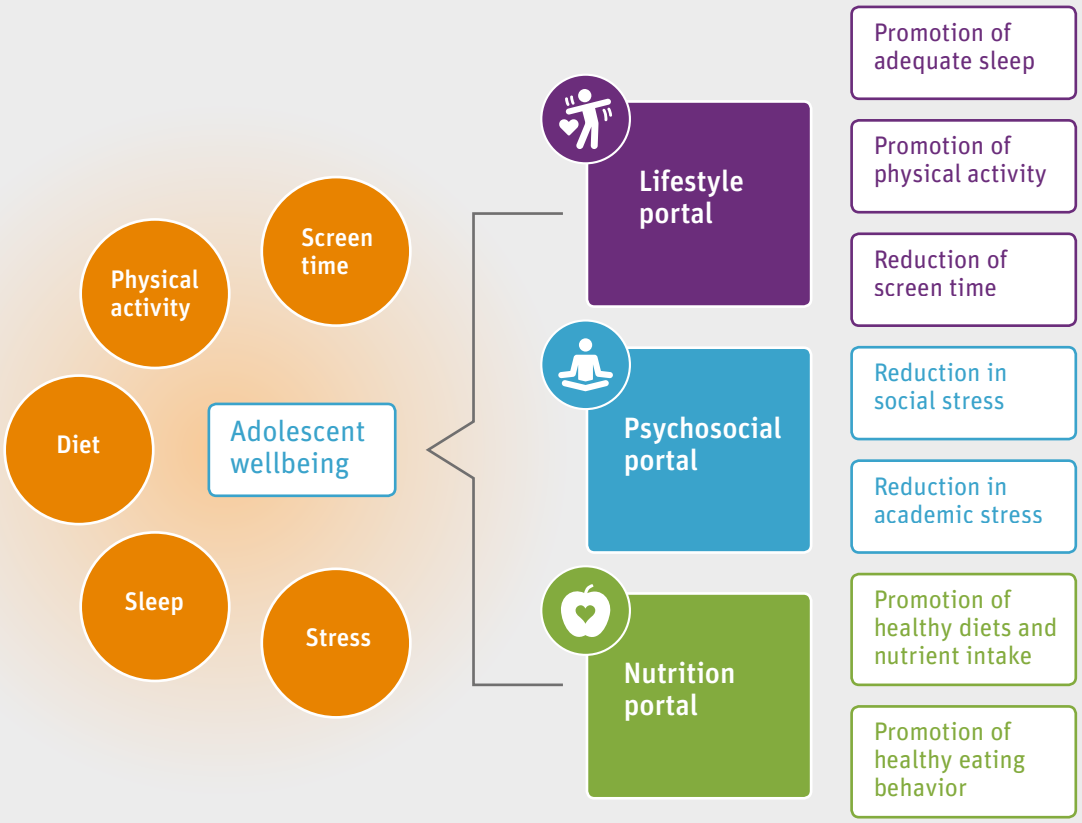
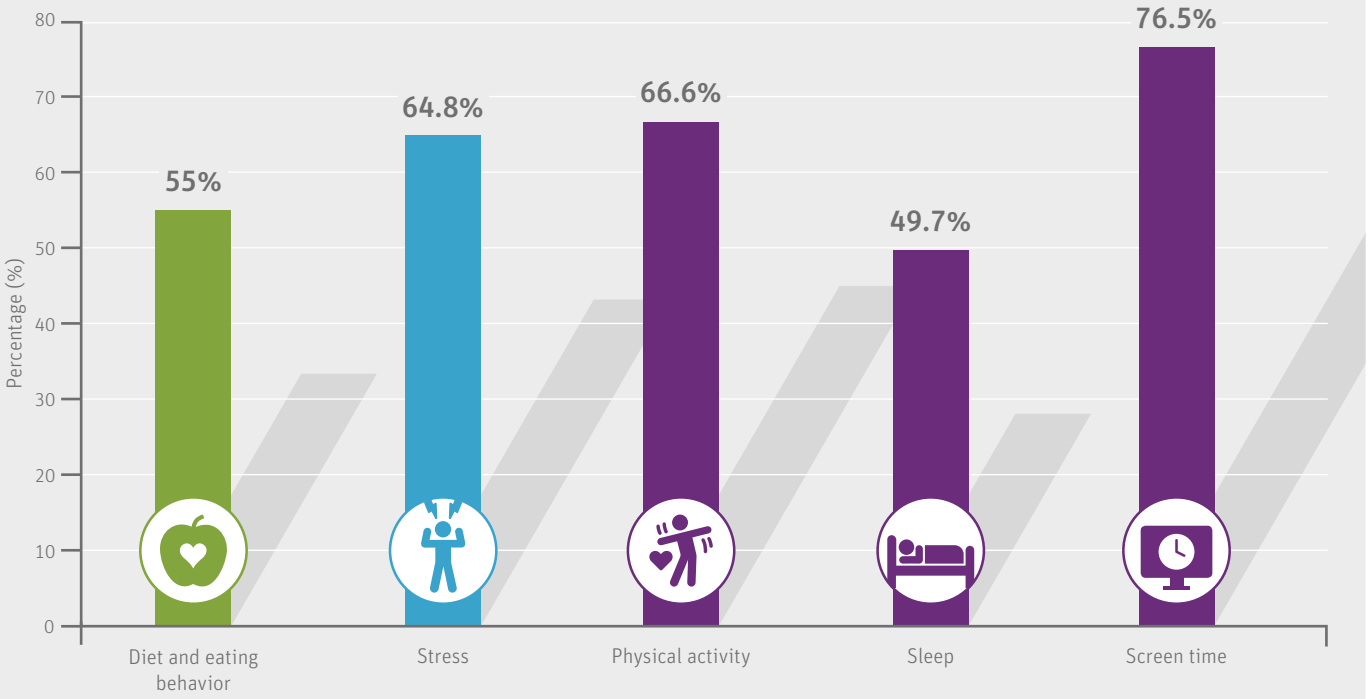


FIGURE 2: Percentage of adolescents needing improvements on the scale of CHELI



sion without considering lifestyle determinants that have a bearing on adolescent wellbeing, a comprehensive index questionnaire has been developed after reviewing a range of validated indices that measure diet, stress, physical activity, screen time and sleep components, using a scoring matrix. The questionnaire has been checked for content validity along with the cutoffs for individual components based on optimal recommendations and guidelines given in validated indices by allotting 'Good', 'Needs improvement' and 'Poor' scores suggestive of maximum, intermediate and minimum bidirectional scores, respectively. The index questionnaire is currently being checked for its construct validity.

The ongoing project on the development of a comprehensive healthy eating and living index (CHELI) has been sponsored by the Indian Council of Medical Research-Indian Council of Social Science Research (ICMR-ICSSR). The questionnaire was administered on a randomly selected sample of 219 adolescents (girls and boys) from urban coeducational schools. It was observed that around 69.9 percent of the adolescents needed improvement in their total CHELI score. Considering the subscores for individual components, adolescents needed improvements in all components as per the recommended guidelines (Figure 2).

Our ongoing study is being carried out among school-going adolescents. Schools serve as a system for long-term improvements in nutrition and lifestyle behaviors of the children, and are the best facilitators for promoting health and nutrition.[31] Schools can serve as a platform for using multisectoral approaches for carrying out nutrition and lifestyle interventions. Such interventions would include blanket coverage of all stakeholders, such as students, peers, parents, teachers, school management and government, who can be dynamically involved in inculcating healthy eating and living among adolescents. Based on the findings obtained at baseline, a targeted communication intervention will be developed using the socioecological framework that assimilates behavior change at different levels of the model.[32]

> "There are very few indices available to measure healthy eating in adolescents"

Potential applications of the index

There are very few indices available to measure healthy eating in adolescents. The one that we are attempting to formulate takes a comprehensive look not only at healthy eating but also at healthy living, and endeavors to integrate nutrition with other health parameters such as stress, physical activity, sleep and screen time, so that the lifestyle determinants are not studied in silos but are assessed as composite factors impacting adolescent nutritional status.

At present, the index is in a nascent stage of development and caters to urban adolescents. However, we envisage a capacity for its additional application to adolescents coming from rural backgrounds. It has a vast scope to be scaled up in various community settings in order to reveal the associations between the risk of diseases and various determinants of adolescent wellbeing.

The final phase of this ICMR-ICSSR-sponsored project aims to develop targeted interventions using a multicomponent, multistakeholder approach that will be reflected through the CHELI scores postintervention.

> "We hope that CHELI can be used as a ready reckoner by healthcare providers, nutritionists and policymakers"

The scalability of CHELI is possible with the support of India's premier national research institutions and government bodies into school-based nutrition policy formulation. At an advanced stage, this index may be used as a self-assessment tool by parents, adolescents and schools for checking the adherence to recommended guidelines given for adolescents and determining their wellbeing. We hope that CHELI, once developed, can be used as a ready reckoner by healthcare providers, nutritionists and policymakers for designing targeted and context-specific health and nutrition interventions for adolescents.

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Elevator Pitch Contest 2018 *Innovations for Aflatoxin-Free Food Systems*

Mumbai, India, 24–26 October 2018

Srujith Lingala, Rebecca Olson
Sight and Life, Basel, Switzerland

Wendy Gonzalez
Global Alliance for Improved Nutrition (GAIN)

As competition for research and investment funds increases, young scientists and entrepreneurs need to effectively articulate their ideas in ways that are persuasive and precise. The Elevator Pitch Contest (EPC), a unique platform devised by *Sight and Life*, is an interactive approach whereby entrepreneurs must boil down their innovative concepts into a persuasive pitch to present in front of a distinguished team of experts, investors and the larger nutrition community.

The third *Sight and Life* EPC was held in Mumbai, India, in October 2018 during the 19th World Congress of the International Union of Food Science and Technology (IUFoST). It was hosted by the Global Alliance for Improved Nutrition (GAIN), in collaboration with *Sight and Life*, Mars, Incorporated and Postharvest Loss Alliance for Nutrition (PLAN), as part of the Business Platform for Nutrition Research (BPNR), co-funded by the Government of Canada.

> "The Elevator Pitch Contest is a great opportunity for young entrepreneurs to communicate their idea, to talk about it, and to learn from mentors and peers about how to improve it and how to connect with others to take the idea further"
>
> *Klaus Kraemer, Sight and Life*

Aflatoxin control

This third EPC, titled Innovations for Aflatoxin-Free Food Systems, sought disruptive ideas in aflatoxin control from students, young professionals and entrepreneurs working in the field of innovative products, services, technologies, applications and approaches for reducing or eliminating exposure to aflatoxin-contaminated foods and feed.

Aflatoxins – toxic metabolites of the Aspergillus flavus and Aspergillus parasiticus fungi – are one of the greatest risks to food security, health and wellbeing in low- and middle-income countries. Over 4 billion people are at risk of chronic exposure to aflatoxins through contaminated foods, which can lead to acute liver damage and liver cancer. Aflatoxins may also be involved in immune suppression, as well as growth impairment in children. Aflatoxins significantly impact trade and economy. The inability to achieve import standards can create barriers to the development of sustainable agriculture, and can lead to huge economic losses for individual farmers and entire countries.

The competition

Open to young entrepreneurs from around the world, the contest drew over 53 entries from 15 countries and 25 universities across diverse categories and stages. Three independent reviewers rated the entries and selected six finalists.

The six finalists were awarded a round-trip to Mumbai, where they presented their ideas for an aflatoxin-free world to a panel of judges, experts and potential investors. The panel of judges included:

- **Klaus Kraemer,** Managing Director, *Sight and Life*
- **Amare Ayalew,** Director of Partnership, Aflatoxin Control in Africa (PACA)
- **Kalpana Beesabathuni,** Global Lead for Technology and Entrepreneurship Lead, *Sight and Life*
- **Mduduzi Mbuya,** Senior Technical Specialist, GAIN
- **Wendy Gonzalez,** Technical Specialist, GAIN

Jury members of the Elevator Pitch Contest in Mumbai, India. From left to right: Dr Klaus Kraemer (*Sight and Life*), Dr Amare Ayalew (PACA), Kalpana Beesabathuni (*Sight and Life*), Dr Mduduzi Mbuya (GAIN) and Dr Wendy Gonzalez (GAIN).

Before the competition, each finalist had the opportunity to receive mentoring and feedback regarding their concept and presentation in order to help hone their pitch. The finalists worked with Nirjhor Rahman, the Country Director of YGAP, an incubator supporting impact entrepreneurs, through multiple group and individual sessions to refine their pitch and improve their narrative. They also met with a previous EPC finalist who shared his experiences of the competition. Kalpana Beesabathuni, a *Sight and Life* team member and the Chief Architect of the EPC, worked with the finalists to create a gripping narrative to help them do their best at the event.

> "We designed the contest in such a way that it provides the tools for young scientists and engineers to communicate their unique ideas in a persuasive manner – in the time it takes to ride an elevator"
>
> *Kalpana Beesabathuni, Sight and Life*

Timeline to conduct the Elevator Pitch Contest

The winners

The winners of the EPC were: Alexandra Warrington from Future Food Now, and Alexandra Sanderson from Kumwe Harvest. Benedikt Suter, Board Member of *Sight and Life* Foundation, and Vish Prakash, Scientific Council Chair for IUFoST, presented the award. Each winner received US$15,000 seed funding to further develop their concept.

Alexandra Warrington presented a solution for using aflatoxin at-risk groundnut cake, a by-product from oil crushing, as feed for insect farming. The innovation encompasses using insect farming technology to remove aflatoxins from at-risk foods, namely groundnuts and potentially also maize, in Malawi. This approach directly removes aflatoxins from the human food chain, as recent studies have shown that insects fed on aflatoxin-

Winners of the Elevator Pitch Contest, Alexandra Warrington and Alexandra Sanderson, with Benedikt Suter, Board Member of *Sight and Life*, and Dr Vish Prakash, Chairman of the IUFoST Conference

contaminated feed do not accumulate aflatoxins. These insects can be used as protein-rich food for human consumption or else used as a nutritious ingredient for inclusion in livestock diets. Alexandra Warrington is a graduate in Food Chain Systems from Cranfield University, UK.

> "It was an invigorating process to watch these passionate development professionals and young entrepreneurs present their innovations, which have the potential to improve food systems globally"
>
> *Mduduzi Mbuya, GAIN*

Alexandra Sanderson and her team from Kumwe Harvest proposed a rapid and controlled, 'just-in-time' postharvest processing model in which maize is aggregated 'on the cob' and processed immediately using high-capacity shelling and drying machines. The process reduces farmer postharvest time to 4 days from the current average of 67 days, virtually eliminating the development of aflatoxins. The process involves buying unshelled maize on the cob from farmers after harvest and transporting it to a central processing facility for immediate shelling and drying, before delivering it to commercial buyers. Alexandra Sanderson is a graduate from the University of Bristol, UK, specializing in quantitative and statistical analysis.

Lessons learned

Lessons learned during the EPC process included:

1. **Engaging the audience:** brochures with briefs of the finalists' ideas, venue and event timings were distributed at the conference. This was helpful in reminding the audience to attend the contest. A professional emcee also hosted the event, which was helpful in keeping the energy levels high and keeping the audience engaged throughout the duration of the event.
2. **Developing crisp presentations:** the contest stressed mentorship as part of the process, and each participant had the opportunity to receive adequate guidance, training and practice time to refine their pitch. This resulted in confident presentations, which made a significant contribution to the success of the event.

3. **Adding value and appeal:** a videographer recorded 30-s introductory videos of all finalists. The respective videos were played before the finalists presented their innovations. This helped the audience and judges connect with the finalists, beyond just the technical concept of their innovation. In addition, a 1-min pitch of all the innovations was recorded and shared with the finalists to help them promote their ideas on various platforms.

Overall, the EPC in Mumbai was a success and the lessons learned will support improvements for future competitions. The six finalists brought this contest to life with their cutting-edge ideas, and we are looking forward to bright futures for all of them:

Alexandra Warrington, Soil Association, Bristol, UK – Future Food Now: Aflatoxin at-risk groundnut cake as a by-product from oil crushing is used as a feed source for insect farming.

Alexandra Sanderson, Kigali, Rwanda – Kumwe Harvest: A rapid and controlled, just-in-time process whereby maize is collected on the cob and processed immediately by utilizing high-capacity machinery.

William Ofori Appaw, Kwame Nkrumah University of Science and Technology, Ghana – Food Logistics: Encapsulating scientifically proven pre- and post-harvest solutions to empower smallholder farmers to reduce aflatoxin contamination in peanut production.

Anthony Phan, Feed the Future Innovation Lab for Horticulture, University of California, Davis, CA, USA – Dry Card: Provides farmers and traders an affordable and simple way to determine whether their products are dry enough and will not produce aflatoxin.

Daniel Cavanaugh, Johns Hopkins University, Baltimore, MD, USA – Clean Crop Technologies.

Emerson Eggers, CO, USA – Dry Chain America: Enabling safe and efficient drying and post-harvest storage with desiccant-based drying beads technology and moisture-proof packaging.

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The six Elevator Pitch Contest finalists and judges. From left to right: Alexandra Warrington (finalist), William Ofori Appaw (finalist), Anthony Phan (finalist), Dr Mduduzi Mbuya (judge), Dr Klaus Kraemer (judge), Dr Amare Ayalew (judge), Dr Wendy Gonzalez (judge), Kalpana Beesabathuni (judge), Emerson Eggers (finalist), Alexandra Sanderson (finalist) and Daniel Cavanaugh (finalist).

Books
Reviews & Notices

Editor's note: This section contains reviews of books, whether brand new or classic, that we hope will be of interest to our readers.

Book Review

Big Brother is Crunching You

Big Data: A Revolution That Will Transform How We Live, Work and Think

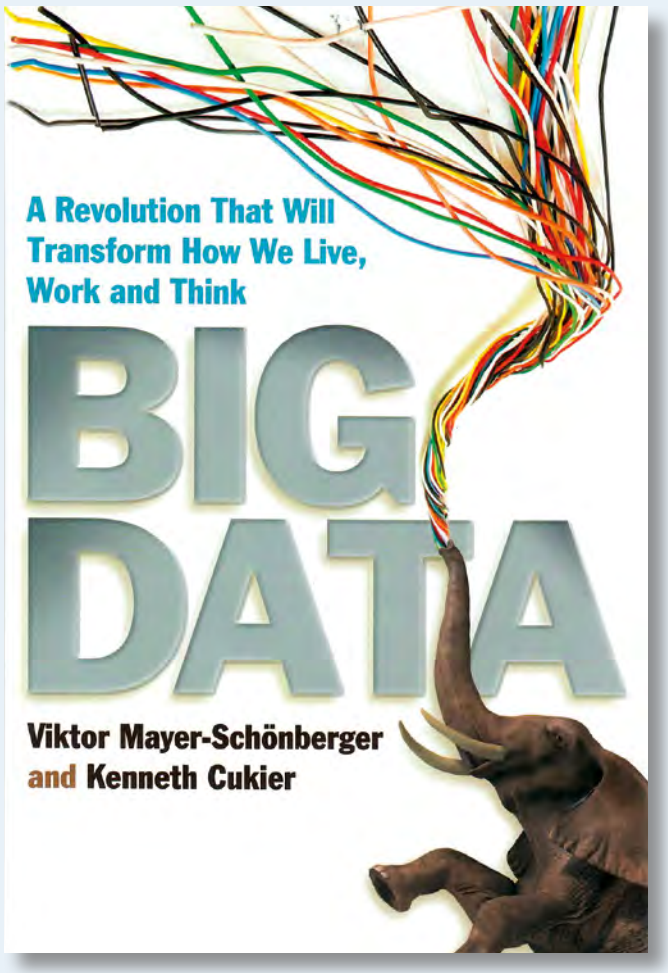
Viktor Mayer-Schönberger and Kenneth Cukier
Publisher: John Murray, London, 2013
Language: English
ISBN: 978-1-84854-790-2

In the 1890 novel *The Sign of Four*, the fictional detective Sherlock Holmes explains to his companion Dr John Watson his approach to the science of detection.

"Oh, didn't you know?" he cried, laughing. "Yes, I have been guilty of several monographs. They are all upon technical subjects. Here, for example, is one 'Upon the Distinction Between the Ashes of the Various Tobaccos.' In it I enumerate a hundred and forty forms of cigar-, cigarette- and pipe-tobacco, with coloured plates illustrating the difference in the ash. It is a point which is continually turning up in criminal trials, and which is sometimes of supreme importance as a clue. If you can say definitely, for example, that some murder has been done by a man who was smoking an Indian lunkah, it obviously narrows your field of search. To the trained eye there is as much difference between the black ash of a Trichinopoly and the white fluff of bird's-eye as there is between a cabbage and a potato."[1]

Sherlock Holmes' interest in tobacco ash, like his interest in all the other 'technical subjects', is designed to generate inferences. If the ash from a particular type of tobacco is found at a crime scene, it may be inferred that a particular type of person might have been present there. Together with other inferences – based on the size of a footprint or the length of a stride, for instance – this tiny detail can be used to create a picture that is not in itself complete but is sufficiently informative to point to the putative suspect. Sherlock Holmes' creator, Sir Arthur Conan Doyle, was in fact responsible for the development of many forensic methods that were subsequently adopted by the British Police.[2]

If Holmes were alive today, he would probably be writing algorithms rather than monographs. For the principles that inform his forensic approach are precisely those that inform big data. As Viktor Mayer-Schönberger and Kenneth Cukier argue in their 2013 book of the same name, big data is " the ability of society to harness information in novel ways to produce useful insights or goods and services of



significant value … The data can reveal secrets to those with the humility, the willingness, and the tools to listen." And they observe that: "Predictions based on correlations lie at the heart of big data."

Predictions based on correlations – not on causality. In this well-researched and carefully structured analysis, the authors argue that society's new ability to dice and slice vast amounts of information will lead to a change in the way we think: "Since Aristotle, we have fought to understand the causes behind everything. But this is starting to change. In the age of big data, we can crunch an incomprehensible amount of information, providing us with invaluable insights about the *what* rather than the *why*." This is a seismic shift. It allows us to make judgements on the basis of *observed relationships* rather than *observed causes* – even if the pictures generated are not complete.

> "Big data allows us to make judgements on the basis of *observed relationships* rather than *observed causes*"

Big data "takes information generated for one purpose and re-uses it for another – in other words, the data moves from primary to secondary sources. This makes it more valuable over time," explain Mayer-Schönberger and Cukier.

Big data reveals patterns that can be interpreted to make predictions about future behavior, and is thus a crucial tool in the effort to improve the delivery of medical services to those who need them, for instance, or in the battle against terrorism. Its application in the service of improved nutrition is extensively discussed in this issue of *Sight and Life* magazine. However, "big data allows for more surveillance of our lives while it makes some of the legal means for protecting privacy largely obsolete. It also renders ineffective the core technical method of preserving anonymity. Just as unsettling," the authors continue, "big-data predictions about individuals may be used to, in effect, punish people for their propensities, not their actions."

Palpably concerned about the potential of the genie they have described, Mayer-Schönberger and Cukier conclude that "Our task is to appreciate the hazards of this powerful technology, support its development – and seize its rewards." Their final sentence is a plea: "We must use this tool with a generous degree of humility … and humanity."

Big data in the hands of a Sherlock Holmes will always make the world a better and a safer place. But, as Sherlock Holmes well knew, his nemesis, the evil Professor Moriarty, was unfortunately every bit as clever as he.

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Imprint

Sight and Life magazine
Incorporating the Xerophthalmia Club Bulletin
and the Nutriview Newsletter

Publisher: *Sight and Life*
Editor: Klaus Kraemer
Editorial team: Madhavika Bajoria, Harriet Burgham, Srujith Lingala, Jonathan Steffen

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Communication consultancy, project management and text writing:
Jonathan Steffen Limited, Cambridge, UK

Design concept, layout and graphics:
S1 Grafik Design, Root, Switzerland
www.s1-buero.com

Proofreading:
Rosemary Boddington, Cambridge, UK

Printer: Burger Druck, Waldkirch, Germany

ISBN 978-3-9524817-9-0

Carbon-neutral production

Conference Reports Online

The following Conference Reports are either already online or else scheduled for posting shortly after going to press.

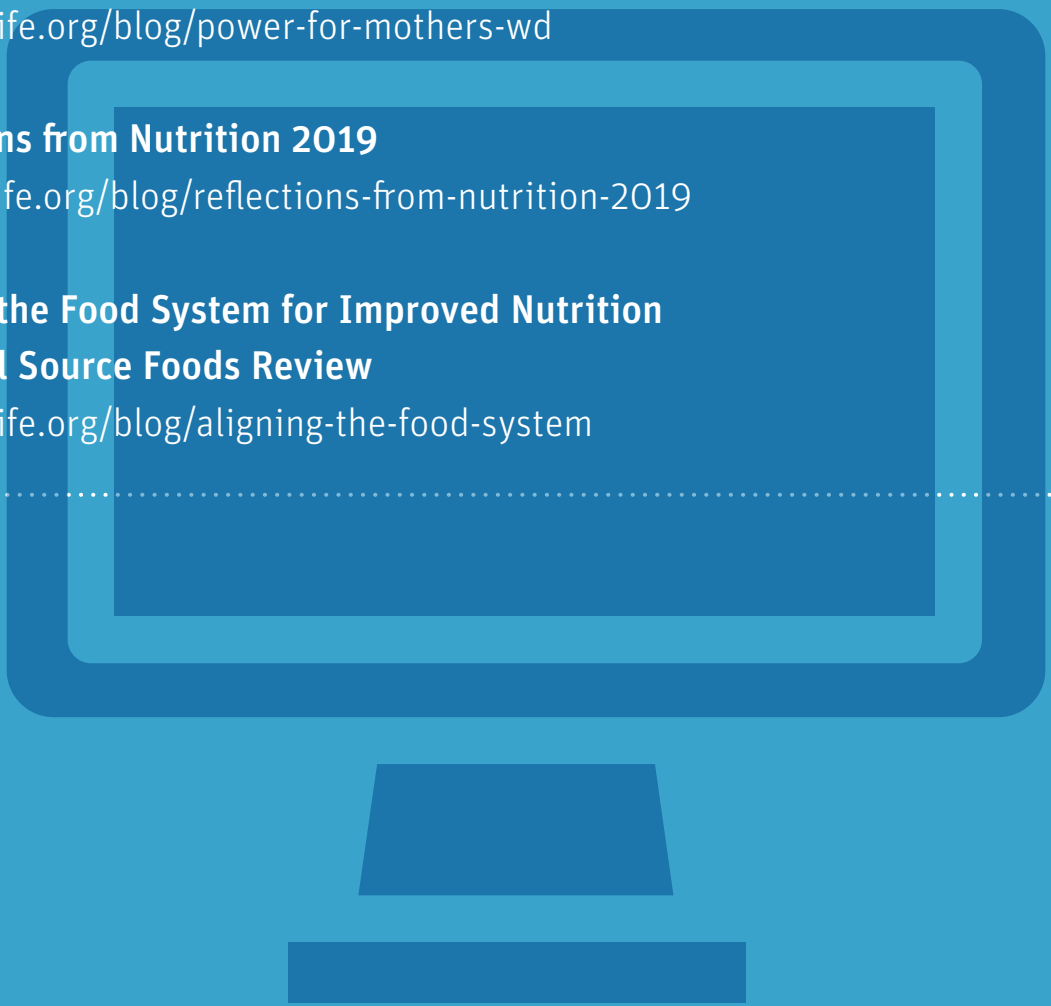
Mexico Hosts the XXII Latin American Congress of Nutrition (SLAN)
sightandlife.org/blog/mexico-hosts-slan

The IV World Public Health Nutrition Congress in Madrid
sightandlife.org/blog/public-health-nutrition-congress

Power for Mothers Advocates for MMS Equality at Women Deliver Conference
sightandlife.org/blog/power-for-mothers-wd

Reflections from Nutrition 2019
sightandlife.org/blog/reflections-from-nutrition-2019

Aligning the Food System for Improved Nutrition in Animal Source Foods Review
sightandlife.org/blog/aligning-the-food-system



A world free from malnutrition.

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Sight and Life is a humanitarian nutrition think tank delivering innovative solutions to eliminate all forms of malnutrition in children and women of childbearing age and improve the lives of the world's most vulnerable populations.

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