ORIGINAL RESEARCH

CURRENT DEVELOPMENTS IN NUTRITION

Intervention Program Methods and Outcomes

Experiences and Lessons Learned in Developing and Implementing a Population-Based Nutrition and Health Surveillance System in Guatemala 2011–2021

Mireya Palmieri,[1] Rafael Flores-Ayala,[2] Karla Mesarina,[1] Dora Inés Mazariegos,[1] Carolina Martínez,[1] Baudilio López,[3] María Claudia Santizo,[4] Ralph D Whitehead, Jr,[2] O Yaw Addo,[2] José Aponte,[5] Eugenia De León Quiñónez,[6] Manuel de Jesús Sagastume,[7] and María Elena D Jefferds[2]

[1]Nutrition and Micronutrients Unit, Institute of Nutrition of Central America and Panama (INCAP), Guatemala City, Guatemala; [2]Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention (CDC), Atlanta, GA, USA; [3]Office of Health and Education, United States Agency for International Development (USAID), Guatemala City, Guatemala; [4]Nutrition, United Nations Children's Fund (UNICEF), Guatemala City, Guatemala; [5]Division of Health Informatics and Surveillance, Center for Surveillance, Epidemiology, and Laboratory Services, Centers for Disease Control and Prevention (CDC), Atlanta, GA, USA; [6]Secretariat of Food and Nutrition Security, Guatemala City, Guatemala; and [7]Department of Epidemiology, Ministry of Health, Guatemala City, Guatemala

ABSTRACT

Background: Practice-based experiences documenting development and implementation of nutrition and health surveillance systems are needed.

Objectives: To describe processes, methods, and lessons learned from developing and implementing a population-based household nutrition and health surveillance system in Guatemala.

Methods: The phases and methods for the design and implementation of the surveillance system are described. Efforts to institutionalize the system in government institutions are described, and illustrative examples describing different data uses, and lessons learned are provided.

Results: After initial assessments of data needs and consultations with officials in government institutions and partners in the country, a population-based nutrition surveillance system prototype with complex sampling was designed and tested in 5 Guatemalan Highland departments in 2011. After dissemination of the prototype, government and partners expanded the content, and multitopic nutrition and health surveillance cycles were collected in 2013, 2015, 2016, 2017/18, and 2018/19 providing nationally representative data for households, women of reproductive age (15–49 y), and children aged 0–59 mo. For each cycle, data were to be collected from 100 clusters, 30 households in each, and 1 woman and 1 child per household. Content covered ~25 health and nutrition topics, including coverage of all large-scale nutrition-specific interventions; the micronutrient content of fortifiable sugar, salt, and bread samples; anthropometry; and biomarkers to assess annually, or at least once, ~25 indicators of micronutrient status and chronic disease. Data were collected by 3–5 highly trained field teams. The design was flexible and revised each cycle allowing potential changes to questionnaires, population groups, biomarkers, survey design, or other changes. Data were used to change national guidelines for vitamin A and B-12 interventions, among others, and evaluate interventions. Barriers included frequent changes of high-level government officials and heavy dependence on US funding.

Conclusions: This system provides high-quality data, fills critical data gaps, and can serve as a useful model for others. *Curr Dev Nutr* 2022;6:nzac027.

Keywords: nutrition surveillance, micronutrients, interventions, food fortification, vitamin and mineral supplementation, Guatemala, women, young children

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Address correspondence to MEDJ (e-mail: mjefferds@cdc.gov).

Abbreviations used: COVID-19, corona virus disease 2019; DHS, Demographic and Health Survey; ICC, intraclass correlation; INCAP, Instituto de Nutrición de Centro América y Panamá; INE, Instituto Nacional de Estadística; ITAG, Interagency Technical Advisory Group; MOU, memorandum of understanding; MSPAS, Ministerio de Salud Pública y Asistencia Social; SAC, school-age child; SESAN, Secretaría de Seguridad Alimentaria y Nutricional; SIVESNU, Sistema de Vigilancia Epidemiológica de Salud y Nutrición; USAID, United States Agency for International Development; WFP, World Food Programme; WRA, women of reproductive age.

Introduction

In response to the 2014 Global Nutrition Report call for a nutrition data revolution (1), global, regional, and national efforts have focused on addressing data gaps and barriers to strengthen the nutrition data value chain (e.g., 2–6). The 2018 Global Nutrition Report specifically highlighted the lack of data on the global micronutrient burden and the need for more surveillance data to achieve global targets (7). No

single data source can serve all data purposes and meet all data needs in a country. Timely, high-quality, population-based nutrition data are key sources of information required by policymakers and program implementers to make evidence-informed decisions. These data are used for nutrition planning and advocacy, to improve nutrition programs and support effective and safe implementation, for accountability of government and agency commitments and investments, to monitor trends in malnutrition, and to track progress to achieve global targets, such as the 2025 World Health Assembly Global Nutrition Targets and the 2030 Sustainable Development Goals (1). There have also been calls to share practice-based and tacit knowledge regarding efforts to strengthen available data (8).

In Guatemala, >40% of children aged <5 y have stunted growth, and >15% have iron deficiency (9); among nonpregnant women of reproductive age, almost 60% have either overweight or obesity, and >17% have iron deficiency (10). In Guatemala, long-term and sustained investment in nutrition-sensitive and nutrition-specific interventions, as expressed in the national food and nutrition annual plan and budget for 2014 to 2018, has been viewed as unstable and insufficient to meet the nutritional needs of all vulnerable groups (11, 12). In Guatemala, evidence to guide policymaking and nutrition program implementation has centered on the Demographic and Health Surveys (DHS) conducted every 5 to 8 y, which provide critical information to the country. The Ministry of Health and other ministries and institutions produce other sources of health and nutrition data through routine systems, but the participation in and coverage of the public health system is ~70% (13). Neither the DHS nor the government information systems provide data on all large-scale nutrition-specific interventions being implemented in the country or micronutrient status of vulnerable populations.

Based on the experiences in Nicaragua with the government establishing the Integrated Surveillance System for Nutrition Interventions with the support of partners, in 2010 the United States Agency for International Development (USAID), the CDC, and the Institute of Nutrition of Central America and Panama (INCAP) began supporting and providing technical assistance to Guatemalan government agencies and other in-country partners to develop a nutritional surveillance system that would satisfy needs for policymaking and effective program implementation, taking into consideration relevant questions that Guatemalan political and technical actors need answered to guide national decisions regarding food and nutrition security. The purpose of this article is to describe the processes, methods, and lessons learned from developing and implementing a population-based national nutrition and health epidemiological surveillance system in Guatemala 2011–2021 (9, 10, 14–23).

Development of the Epidemiological Health and Nutrition Surveillance System

There were multiple steps in the development of the Epidemiological Health and Nutrition Surveillance System (SIVESNU, Spanish acronym). To understand the nutrition information landscape and data needs, and to explore the environment for a potential surveillance system, USAID, CDC, and INCAP teams conducted exploratory meetings in September and December 2010 with leadership and technical members from the Ministry of Health (MSPAS, Spanish acronym), the Food and Nutrition Security Secretariat (SESAN, Spanish acronym), and later in the process with other representatives of the Guatemalan government. Meetings also occurred with other organizations in the country (e.g., UNICEF, World Food Programme, Mesoamerican Food Security Early Warning System). In 2010, there was no population-based, timely, high-quality national data collection platform to support evidence-based decision making, including providing estimates of anthropometry indicators; micronutrient status of vulnerable populations; and performance of all large-scale nutrition-specific interventions in the country, especially industrial food fortification. Due to upcoming 2012 presidential elections, the decision was made to initially design and test a prototype of a surveillance system to fill these gaps with the expectation that the system would be launched after the elections. Plans were made to create an Interagency Technical Advisory Group (ITAG) to guarantee the relevance and need and use of the surveillance content and assure the flow of technical assistance and financial contributions to the national effort led by INCAP. At that time, through discussions with the different institutional teams, a management model was designed for future planning and budget activities taking into consideration INCAP's budget cycles and norms under their administrative framework, with the expectation the system would eventually be institutionalized within the Government of Guatemala.

The prototype was designed including all analytical, technical, and field processes; data collection occurred in 2011 and was representative of 5 departments in the Highlands of Guatemala (14). After the prototype was tested, partners requested an expansion of content, particularly reproductive and maternal child health indicators (**Table 1**). A nationally representative system was designed, with the first national data collection taking place in 2013, including a focus to carry out the technological transfer of all capabilities and resources to a government institution responsible for monitoring and evaluating national health policies and programs—the MSPAS. From 2015 onwards, all efforts have been directed to the "institutionalization" of the system at SESAN, which is mandated to monitor and evaluate multisectoral and sectoral food and nutrition policies and programs. The MSPAS is a first-level executive body in the structure of the Guatemalan government that manages the public health sector, whereas SESAN is a presidential-level multisectoral coordination body.

Methods

SIVESNU design

The SIVESNU is a complex, cross-sectional, continuous multitopic nutrition and health household survey with multistage sampling designed to be nationally representative of households, women of reproductive age (WRA, 15–49 y), and children aged 0–59 mo on an approximately annual basis. The overall SIVESNU 2013 sample size calculations and assumptions described below were unchanged and applied to the 2015, 2016, 2017/18, and 2018/19 SIVESNU cycles. Published SIVESNU reports include details about the study area, study population, and sampling strategy (15–17, 19, 23).

In 2013, for the first stage of sampling, the Guatemalan National Statistics Institute (INE, Spanish acronym) used the 2002 national sampling frame, which included 5600 enumeration areas (clusters), to select 100 clusters using probability proportional to size sampling. The selected clusters were updated in the field by cartographers who produced new cluster maps that were digitalized and printed. After this,

TABLE 1 Questionnaire topics included in SIVESNU cycles 2013, 2015, 2016, 2017/18, and 2018/19, Guatemala, and question sources[1]

Topic (source)	2013	2015	2016	2017/18	2018/19
Household census (27, 28)	X	X	X	X	X
Household- and population-specific characteristics (27, 28)	X	X	X	X	X
Socioeconomic status (21)	X	X	X	X	X
Household food security (29–31)	X	X	X	X	X
Water, hygiene, and sanitation (27, 28)	X	X	X	X	X
Availability and intake of fortifiable foods in the household (32)	X	X	X	X	X
Women's dietary diversity[2]	X	X	X	X	X
Pregnancy history and births (35)	X	X	X	X	X
Antenatal and postnatal care (35)	X	X	X	X	X
Family planning (35)	X	X	X	X	X
Access and coverage of other governmental health, nutrition, and food security programs (27, 28)	X	X	X	X	X
Smoking habits (35)	X	X	X	X	X
Vitamin and mineral supplementation and micronutrient powder coverage (35)	X	X	X	X	X
Deworming coverage (35)	X	X	X	X	X
Immunizations (35)	X	X	X	X	X
Morbidity (35)	X	X	X	X	X
Infant and young child feeding practices (36)	X	X	X	X	X
Growth monitoring (35)	X	X	X	X	X
Oral hygiene[3]			X	X	X
Diabetes (37)			X	X	X
Hypertension (37)			X	X	X
Zika[4]				X	X
Physical activity (38)				X	X
Early child development (39)				X	X
Eating at school[5]				X	
Food perceptions and preferences[5]				X	

[1] SIVESNU, Sistema de Vigilancia Epidemiológica de Salud y Nutrición.
[2] SIVESNU 2013, 2015, and 2016 cycles (33); SIVESNU 2017/18 and 2018/19 cycles (34).
[3] Questions provided by the Oral Health Program, Guatemalan Ministry of Health.
[4] Questions from an unpublished concept note, Zika on infection and neurological symptoms among women of reproductive age in Guatemala, 2017.
[5] Questions from an unpublished research protocol by the Instituto de Nutrición de Centro América y Panamá and the Bloomberg School of Public Health, Johns Hopkins University, on obesity and risk factors of cardiovascular disease in school-age children in poor urban areas of Guatemala, 2010.

using a random start and interval, INE randomly selected 30 households to be visited in each cluster (3000 households in total). A census was conducted within each household and data were collected from 1 randomly selected woman of reproductive age (who could or could not be pregnant), and 1 randomly selected child. There was no replacement of clusters, households, WRA, or children for any reason. These procedures were followed for all SIVESNU cycles between 2013 and 2018/19, with slight variation (**Table 2**). In the SIVESNU 2017/18 cycle, a sample of school-age children (SAC) was included with 1 child aged 6–14 y randomly selected per household. In the 2018/19 cycle, in addition to randomly selecting 1 child aged 0–59 mo for participation in the complete survey, anthropometry was also collected among all children aged 0–59 mo in the household.

For the 2013 SIVESNU, the sample size calculations were based on the 2008/09 DHS results and used a formula to identify changes between 2 surveys with the same sample size to detect changes in the prevalence of anemia in nonpregnant WRA and of prevalences of stunting and anemia in young children, powered to monitor trends over data collection cycles. Taking into consideration the 2008/09 DHS response rates, households with a woman of reproductive age, households with a child <5 y, pregnancy status, and design effects, the calculated sample sizes were 2295 WRA, 1194 young children, and 3000 households. Blood and urine were collected from all WRA, and anthropometry for nonpregnant women. Blood (6–59 mo only) and anthropometry were collected from all selected children (Table 2). In some SIVESNU cycles after 2013 only subsamples of some of the biomarker data were analyzed due to budgetary limitations or logistical constraints (e.g., modified relative dose response test for assessment of vitamin A liver stores).

For nutrient testing, potentially fortifiable foods were collected from households (salt to test iodine, sugar to test iron and vitamin A) or nearby stores (bread to test iron); however, over the SIVESNU cycles, the fortified foods, sample sizes, and nutrients analyzed varied (**Table 3**). In the 2013 cycle, samples of salt were collected from 6 randomly selected households per cluster for individual quantitative analysis, and 2 samples of sugar were collected from each of 6 randomly selected households to produce 2 composite sugar samples per cluster (each household contributed 1 sample to include in each of the 2 composite samples per cluster). Starting in 2015, salt and sugar were collected for individual quantitative analysis, with salt samples collected from 8 randomly selected households and sugar samples collected from 3 randomly selected households per cluster; there was no replacement for lack of salt or sugar in the household, and the expectation was to collect ≥600 salt and ≥200 sugar samples per cycle. Families were asked where they most frequently purchased bread, then bread was purchased

TABLE 2 Final number of clusters and sample sizes of households, women of reproductive age (15–49 y), children aged 0–59 mo and 6–59 mo, and school-age children (6–14 y) reported in SIVESNU cycles 2013, 2015, 2016, 2017/18, and 2018/19, Guatemala[1]

Sample sizes	2013	2015	2016	2017/18	2018/19
Clusters[2]	96	97	96	96	97
Households	2403	2304	2380	2424	2491
Nonpregnant women of reproductive age with complete interview	1735	1628	1647	1642	1658
Nonpregnant women of reproductive age with complete interview, anthropometry, and laboratory	1655	1617	1493	1435	1494
Pregnant women of reproductive age with complete interview	120	99	101	99	97
Pregnant women of reproductive age with complete interview and laboratory	119	92	93	90	86
Children 0–59 mo with complete interview	1008	891	961	885	899[3]
Children 6–59 mo with complete interview, anthropometry, and laboratory	878	690	586	555	602
School-age children 6–14 y with complete interview	NA	NA	NA	1205	NA
School-age children 6–14 y with complete interview, anthropometry, and laboratory	NA	NA	NA	978	NA

[1]School-age children sample only included in 2017/2018 cycle. NA, not applicable; SIVESNU, Sistema de Vigilancia Epidemiológica de Salud y Nutrición.
[2]When <100 clusters are included either the community refused to allow the cartographers to update the maps, or the community refused data collection by SIVESNU field teams. Used same clusters in 2015 and 2016, and in 2016 carried out a new random selection of 30 households in clusters, and of the population groups within those 30 households.
[3]In 2018/19, anthropometry also collected from all children aged 0–59 mo in the household ($n = 1158$).

from the store with the most responses in each cluster, for a maximum of 100 bread samples.

Field teams and training

With the aim of collecting high-quality data and reducing error, the number of field teams and field team make-up was kept as small as possible for each SIVESNU cycle, with the implication that data collection would be continuous for ~8 mo of the calendar year for most SIVESNU cycles. Field teams per cycle varied from 3 to 5 and included a team supervisor, 2 enumerators/anthropometrists, a laboratory technician, and driver; more recently, the field team added 1 laboratory technician supervisor.

INCAP conducted training for each SIVESNU cycle. For each training, INCAP prepared and updated fieldwork and laboratory manuals for the training sessions and for reference during data collection. These tools allowed field teams, supervisors, and technical observers to monitor adherence to norms and procedures applied in the field to assure quality and reliability. Training was developed based on an instruction plan that laid out knowledge and competency objectives related to local planning and management by supervisors, data collection following all enumerator and laboratory techniques, anthropometric and biomarker collection and measurement by enumerators and laboratory technicians, including classroom instruction, anthropometry practice, and standardization exercises, and a field pilot of all procedures. Training occurred immediately prior to each SIVESNU cycle and lasted ~10–14 d. High-performing field team members often were rehired over multiple SIVESNU cycles.

Data collection

It was necessary to first obtain permission from various departmental, municipality, and community leaders before collecting data in the clusters. Advance teams were deployed to hold meetings with governors, mayors, SESAN's and MSPAS's departmental and municipal delegates, departmental police departments, and community development councils to inform them about planned visits, and to assure collaboration and enhance mutual trust. After contacting community-level committees and securing their collaboration to improve the trust of the local population, team supervisors applied field-level strategies for identification, distribution, and allotment of households in cluster maps to respective teams. Then, supervisors and enumerators walked to the house for the interview, collected georeferenced measurements, and the supervisor scheduled the visit of the team's laboratory technician to collect biological specimens from the randomly selected woman of reproductive age and child. Data collection lasted ~3 d in each cluster. During

TABLE 3 Food specimens collected and nutrients tested as reported in SIVESNU cycles 2013, 2015, 2016, 2017/18, and 2018/19, Guatemala[1]

Foods	2013, *n*	2015, *n*	2016, *n*	2017/18, *n*	2018/19, *n*
Salt, iodine	572	553	553	554	600
Sugar, vitamin A[2]	—	208	258	—	293
Sugar, iron	193	208	258	217	289
Bread, iron	71	95	96	96	97

[1]SIVESNU, Sistema de Vigilancia Epidemiológica de Salud y Nutrición. Iodine was assessed by microplate kinetic methods. Vitamin A was assessed by quantitative spectrophotometric method. Iron was assessed by acid microwave digestion, followed by atomic emission spectrometry.
[2]Dash indicates not analyzed in this SIVESNU cycle.

the initial days of each surveillance cycle, supervisors carried out additional supervision rounds that covered each enumerator in their team to confirm the correct application of the questionnaires, that rapport was established with every informant, the reliability of the answers that were given, and the collection of high-quality anthropometry measurements. Supervisors maintained updated data collection status reports.

Before starting the interview, the enumerator secured informed consent from all participants. Caregivers gave informed consent for children and adolescents. There was no compensation for agreeing to participate in data collection. Data were collected using 4 administered questionnaires including a household questionnaire, WRA questionnaire, young child questionnaire, and store/bakery questionnaire; in the 2017/18 SIVESNU a school-age child questionnaire was also administered. An adult familiar with household purchases was interviewed for the household questionnaire and the randomly selected woman of reproductive age was interviewed for the WRA questionnaire. The mother or caregiver of the randomly selected young child completed the young child interview. A person who worked at the store/bakery where bread samples were collected answered the bakery questionnaire. In SIVESNU 2017/18, the mother or caregiver provided the interview answers for children aged 6–9 y, whereas children aged 10–14 y answered the questions themselves. Interviews were conducted in Spanish or in one of the indigenous Mayan languages based on participant preference, and, if needed, simultaneous translation was carried out by a community member.

Paper-based questionnaires were used for data collection in SIVESNU 2013, and starting in 2015 the household, WRA, and young child questionnaires were converted to 7 Epi Info instruments for tablets for electronic data collection. Since 2013, questionnaire and biological content have been further revised for multiple SIVESNU cycles based on stakeholder priorities and needs (Tables 1–4). Validated global questionnaire content modules were used when possible. For each SIVESNU cycle, any new topics were researched, questions were designed and validated in the field, the training plan was updated, and new procedures were taught by specialists at INCAP.

For anthropometry, following standard procedures (24, 25) recumbent length (ages 0–23 mo) or standing height (ages ≥24 mo) was measured without shoes to the nearest 0.1 cm using a standard length/height-measuring board (ShorrBoard; Weigh and Measure LLC). Weight was measured with light clothing to the nearest 100 g using an electronic digital floor scale (Seca 874). Starting in SIVESNU 2016, waist and hip circumferences of WRA were measured in centimeters using a tape against the skin at the narrowest part of the waistline after exhalation for waist circumference, and using a tape around the buttocks in a horizontal plane without compressing the skin, respectively (25). Anthropometry was not collected from pregnant participants.

Starting in 2016, enumerators measured blood pressure of WRA using the MDF Lenus Digital Blood Pressure Monitor arm cuff (MDF Instruments) on the left arm after the participants were seated for ≥5 min. Three blood pressure measurements were taken 1 min apart, and the second and third measurements were averaged (26).

Blood samples were collected to assess anemia, micronutrient status, infection and inflammation status, and other health indicators and varied by year and population group, with only subsamples collected or analyzed for some indicators (**Table 4**). Urine was collected from women to assess urinary iodine concentrations. Blood and urine (10–20 mL) were collected at the time of interview, and for the subsample participating in the modified relative dose response test the blood collection occurred 4–6 h after vitamin A-2 dosing. Venous blood was collected for all SIVESNU cycles except SIVESNU 2013 and 2015, when pooled capillary blood was collected for all biomarkers, and venous blood for the modified relative dose response test and zinc; volumes of venous blood collected varied by SIVESNU cycle depending on the number of indicators assessed per population group, and ranged from 500 μL to 9 mL for WRA, and 500 μL to 7 mL for young children; the volume was 7 mL for SAC aged 6–14 y in SIVESNU 2017/18.

Point-of-care tests, such as for hemoglobin (HemoCue Hb 301 analyzer) and hemoglobin A1c (Bayer A1CNow+ self-check tests, in 2016 cycle), were conducted in the households. In the 2017/18 and 2018/19 cycles, instead of the Bayer A1CNow+ self-check test, hemoglobin A1c was measured at the INCAP laboratory using Siemens 5035C kits. In addition to the HemoCue Hb 301 analyzer autocalibration, Eurotrol liquid controls (low, middle, high levels) were used daily. Participants were referred to the local government health clinic on the day of data collection when tests conducted at the household identified anemia, high blood pressure, or in SIVESNU 2016 (only cycle tested while still in the household), elevated hemoglobin A1c.

Blood samples were kept at 2–8°C in portable coolers with thermometers until they were processed at the end of the day in the field using centrifuges; whole blood was processed before freezing. Depending on the part of the country where data collection occurred, after processing serum and plasma samples were stored frozen in regional freezers or, more recently, transported directly to INCAP's laboratory in Guatemala City in extruded polystyrene foam (Styrofoam) coolers with internal insulated bubble liners with frozen icepacks. The tubes were maintained at −20°C at INCAP until they were sent to the VitMin Lab in Germany or analyzed at INCAP or another in-country laboratory. Urine samples were collected in wide-mouth cups and later transferred to plastic tubes. These samples were kept in the field cooler with the blood, and later refrigerated at 2–8°C until analyzed at INCAP.

In households, to collect food specimens the enumerators stirred the salt and sugar in the household container holding each food using a new plastic spoon and collected 100 g (10 spoonfuls) of salt and 250 g (25 spoonfuls) of sugar into plastic bags as individual samples. Participants were asked at which store they most frequently purchased sweet or sliced bread, and at the single store mentioned most frequently by cluster participants, 10 units of sweet or sliced bread were purchased per cluster. The bread was weighed immediately after purchase.

Data management, analysis, and dissemination

In SIVESNU 2013, personnel at INCAP's Computing Center conducted double data entry of the paper questionnaires. For 2015 and beyond, a set of individual sync files, by device, were produced in the field and sent to headquarters during data collection for integration and cleaning. INCAP anonymized data at the database cleaning stage. Reviewed and cleaned deidentified databases were exported from the Epi Info platform to an XML format and later sent to the data analyst. SAS 9.2 (SAS Institute) and SPSS (IBM) were used to conduct all analyses, which accounted for the complex survey design. There was no additional weighting to account for nonresponse. Since 2011, INCAP has been responsible for the security of personally identifiable data. There have been no data breaches since initiation of the surveillance system.

TABLE 4 Biomarkers assessed from blood and urine, blood pressure measurement, and anthropometry in SIVESNU cycles 2013, 2015, 2016, 2017/18, and 2018/19, Guatemala[1]

Biomarkers[2]	2013	2015	2016	2017/18	2018/19
Hemoglobin	NPW, PW, C	NPW, PW, C	NPW, PW, C	NPW, PW, C, S	NPW, PW, C
Ferritin	NPW, PW, C	NPW, PW, C	NPW, PW, C	NPW, PW, C, S	NPW, PW, C
Serum transferrin receptor	NPW, PW, C	NPW, PW, C	NPW, PW, C	NPW, PW, C, S	NPW, PW, C
Retinol-binding protein	NPW, PW, C	NPW, PW, C	NPW, PW, C	NPW, PW, C, S	NPW, PW, C
Retinol[3]	NPW, PW, C	—	NPW, PW, C	NPW,[4] PW,[4] C,[4] S[4]	NPW,[4] PW,[4] C[4]
Modified relative dose response[3]	NPW, PW, C	—	NPW, PW, C	NPW,[4] C,[4] S[4]	NPW,[4] PW,[4] C[4]
Urinary iodine concentration	NPW, PW	NPW, PW	NPW, PW	NPW, PW, S	NPW, PW
Zinc	NPW, [3] C[3]	—	NPW,[3] C[3]	—	C[4]
Vitamin B-12	—	—	NPW, PW, C	—	—
Vitamin D [25(OH)D]	—	—	NPW,[3] PW,[3] C[3]	NPW,[4] PW,[4] C[4]	—
Serum folate[4]	—	—	NPW, PW	—	—
RBC folate	—	—	NPW, PW	—	—
C-reactive protein	NPW, PW, C	NPW, PW, C	NPW, PW, C	NPW, PW, C, S	NPW, PW, C
α1-Acid glycoprotein	NPW, PW, C	NPW, PW, C	NPW, PW, C	NPW, PW, C, S	NPW, PW, C
Hemoglobin A1c	—	—	NPW	NPW	NPW
Zika	—	—	—	NPW, PW[4]	NPW, PW[4]
Thyroglobulin	—	—	—	—	NPW,[4] PW
Blood pressure	—	—	NPW	NPW, S[5]	NPW
Length/height and weight	NPW, C	NPW, C	NPW, C	NPW, C, S	NPW, C
Waist and hip circumference	—	—	NPW	NPW, S	NPW

[1]C, children aged 6–59 mo; NPW, nonpregnant women of reproductive age; PW, pregnant women of reproductive age; S, school-age children 6–14 y; SIVESNU, Sistema de Vigilancia Epidemiológica de Salud y Nutrición.

[2]Hemoglobin analyzed using HemoCue HB 301 analyzer with plasma tubes containing anticoagulant K_2EDTA; ferritin, serum soluble transferrin receptor, retinol-binding protein, α1-acid glycoprotein, and C-reactive protein analyzed using ELISA (40) with plasma tubes containing anticoagulant K_2EDTA (SIVESNU cycles 2013, 2015, 2016) or with serum tubes (SIVESNU 2017/18 and 2018/19); retinol and modified relative dose response analyzed using HPLC with serum tubes; urinary iodine concentration analyzed using ammonium persulfate method; zinc analyzed using atomic emission spectrometry and with zinc-free collection and storage supplies; serum and RBC folate, vitamins B-12 and D analyzed using chemiluminescence with serum tubes; hemoglobin A1c in 2017/18 analyzed using Bayer A1CNow+ self-check tests and in 2018/19 using Siemens 5035C kits with plasma tubes containing anticoagulant K_2EDTA; Zika analyzed using ZIKV Detect 2.0 IgM Capture ELISA (InBios) with serum tubes; thyroglobulin analyzed using electrochemiluminescence; blood pressure measured using MDF Lenus Digital Blood Pressure Monitor arm cuff; length/weight measured using ShorrBoard; waist and hip circumference measured using a measuring tape.

[3]Subsample.

[4]Laboratory analysis delayed until 2021 or later.

[5]Limited to children aged 10–14 y.

SIVESNU results were disseminated in final reports and presentations to policymakers and donors, including in December 2016 and December 2017 to the National Council of Food and Nutrition Security, which was led by the Vice-President of Guatemala and was attended by a group of ministers of government agencies as well as other partners. Special meetings have been organized with MSPAS to deliver the most important findings. Databases and documentation of SIVESNU cycles were prepared for public posting and given to SESAN (available at: https://www.siinsan.gob.gt/siinsan/monitoreo-y-evaluacion/#).

SIVESNU costs and funding

A SIVESNU cycle cost ~$350,000 to collect data and produce the report. This included the fieldwork supplies, drawing sample clusters and updating maps, training, supervision, salary and per diem, car rental and fuel, data cleaning and analysis, report writing, printing, office supplies, and other miscellaneous expenses. It also included analysis of a core group of biomarkers, including hemoglobin, iron, and inflammation indicators, but not all other laboratory analysis costs, which varied based on the number and type of biomarkers and food analysis included, or inclusion of an additional population group. In 2017/18 when a SAC sample was included, costs increased by ~$50,000. CDC provided in-kind technical assistance for design, capacity building, conducting and/or reviewing data analyses, and CDC technical report clearance approval, which were not included in the above cost estimate. SIVESNU received funding and/or in-kind office space, laboratory installations, or technical assistance from the INCAP, USAID, and CDC (2011, 2013, 2015, 2016, 2017/18, and 2018/19 cycles), UNICEF (2016, 2017/18, and 2018/19 cycles), and the World Food Programme (2013, 2015 cycles) for the surveillance system.

Ethical approval

For ethical approval, the 2011 prototype proposal was approved by INCAP's ethical approval committee. Starting with the 2013 cycle, the protocol and questionnaires were approved by the MSPAS's National Ethics Committee. For each subsequent data collection cycle (2015, 2016, 2017/18, 2018/19, and 2021/22), the National Ethics Committee approved a request to continue and amend the protocol based on any changes in the population groups, indicators, or procedures. CDC determined that the surveillance system was not research and that based on the CDC staff's role, they were not engaged in human subjects' research. All participants gave informed consent, and caregivers gave informed consent for children and adolescents; there was no direct compensation or incentive given to participate.

Results

Government of Guatemala capacity building and institutionalization

After the 2011 prototype was tested, efforts were directed to the technological transfer of all capabilities and resources to the Government of Guatemala for the institutionalization of SIVESNU in an agency responsible for monitoring and evaluation of national health, food, and nutrition policies and programs. Institutionalization was envisioned to include the assignment of dedicated government staff and annual SIVESNU funding in the national budget, as well as the technical ability to design the questionnaire in each cycle including removing, revising, or adding new questions and modules, conducting training and field supervision, data management and analysis, and report writing and dissemination, with the aim to ensure the development and maintenance of competences to progressively plan, implement, and disseminate the full survey with little external support.

Starting in 2013, efforts focused on promoting the involvement of central-level MSPAS units and officials in the SIVESNU implementation, after which the MSPAS requested INCAP to provide technical assistance to their then National Center of Epidemiology, in charge of regular institutional epidemiological surveillance in the Ministry. Various members of the Center participated in training and standardization sessions, data collection, and analysis throughout the year. At the same time, SIVESNU's coordinator worked with government counterparts and partners in the preparation of a memorandum of understanding (MOU), focused on establishing coordination among the parties and defining the roles, responsibilities, and commitments related to the successful implementation of the SIVESNU system and, specifically, to define the activities related to the institutionalization. The MOU was signed by a Minister of Health in the third quarter of 2014, but he was replaced shortly after signing and the agreed MOU did not move forward. In 2016, a new MOU was drafted and circulated but never signed.

Starting in 2015, 3 types of activities were developed together with SESAN. First, INCAP engaged with SESAN in the joint planning of annual surveillance cycles and to define the Secretary's priorities and assure ongoing institutional support. Second, SESAN staff participated in data management and analysis training sessions, fieldwork activities, and data interpretation. Finally, SIVESNU was included in SESAN's annual planning and budget exercises in 2017; however, funds have not yet been received; and in late 2019, SIVESNU was included in a new MOU draft, which remains unsigned. From 2013 to date, SIVESNU funding continues to come from non–Government of Guatemala international partners and donors.

Despite these efforts, national political changes have affected institutional viability and effectiveness at both MSPAS and SESAN: during the period from 2012 to 2018, both institutions experienced repeated turnover of high-level officials. At the MSPAS, there were 8 different Ministers, who each brought new staff, in 6 y. Turnover was less frequent in SESAN, but the change of the SESAN Secretary in 2017 in the middle of the SIVESNU institutionalization process resulted in changes to institutional priorities and strategies in monitoring and evaluation. Despite the turnover and discontinuity of priorities and decisions, with few exceptions, there has been strong interest among the technical counterparts in both institutions and among partners to institutionalize and include the surveillance system in annual plans and budgets. The SIVESNU data have been used to support evidence-based policy and program decisions.

Examples of uses of SIVESNU data and platform

SIVESNU data are key for monitoring trends in critical public health problems, such as stunting in children aged <5 y; overweight and obesity in nonpregnant WRA; anemia, iron, and vitamin A status in children and women; and iodine status in women. SIVESNU provides key coverage monitoring data of large-scale public health interventions and has resulted in program and policy revisions, such as scaling down

biannual high-dose vitamin A supplementation for children from ages 6–59 mo to 6–11 mo, based on effective sugar fortification and adequate vitamin A status in young children, as well as the inclusion of vitamin B-12 to the maize flour fortification premix based on evidence of deficiency. The International Food Policy Research Institute used SIVESNU's 2016 and 2018 data for their evaluation of the 7-department strategy to reduce chronic malnutrition, which was coordinated by SESAN. Data collected were used to evaluate the impact of key interventions developed by the national strategy, particularly those targeted to reduce stunting. In 2020, before the COVID-19 pandemic, planning occurred to use the SIVESNU platform to evaluate the new Presidential administration's stunting reduction strategy; however, the pandemic prevented 2020 data collection. For the 2021 Baseline Survey of the President's stunting reduction strategy, which also serves as the SIVESNU 2021/22 cycle with considerable content overlap, field teams were vaccinated against COVID-19, had strict COVID-19 mitigation measures in place, and data collection began in April 2021. As a flexible platform, SIVESNU content could be revised during the planning phase of each cycle. Multiple micronutrient biomarkers of public health importance have been included in different SIVESNU cycles. As part of the emergency response to the Zika outbreak, nationally representative data were needed for planning Zika response activities within the MSPAS. In the 2017/18 cycle, questions were included regarding environmental conditions at the household level, Zika-like symptoms in WRA, family-planning decisions based on the Zika outbreak, and neurological symptoms in WRA, and blood samples from WRA were analyzed for indicators of recent and current Zika infection. The questions were continued in the 2018/19 SIVESNU cycle. Biomarkers were also collected to assess endemic kidney disease and liver function, but when funding was delayed the specimens remained frozen and the laboratory analyses did not occur. Between SIVESNU cycles 2017/18 and 2018/19, the SIVESNU platform was also used to conduct a departmental SIVESNU that generated representative data for the department of Huehuetenango (18), one of the largest departments in both population and geographic size, and the data were used to inform local planning.

Discussion

Lessons learned

Reviewing SIVESNU's development and implementation over the last 10 y, the interinstitutional team has identified strengths and weaknesses. SIVESNU is a flexible data collection platform that produces nationally representative high-quality data at low cost compared with similar surveys in similar countries for all large-scale nutrition-specific interventions in the country, as well as other critical health conditions and interventions. Multiple attempts were made to institutionalize SIVESNU and build capacity within government institutions with a mandate of carrying out regular surveillance, monitoring, and evaluation activities (including MSPAS, SESAN, and the National Presidential Planning Secretariat) for them to independently run and contribute financially to SIVESNU; however, staff turnover of government leadership and changing priorities have been barriers. Institutionalization discussions continue, and government staff and partners have consistently provided technical input regarding the content of each of the cycles, received reports, and participated in dissemination events, and SESAN has received SIVESNU datasets and documentation and posted them publicly on their website.

Initially, the expectation was that the ITAG would meet routinely to make decisions regarding SIVESNU cycles and to review data produced. Meetings have occurred inconsistently, and partner input is often carried out bilaterally directly with the SIVESNU coordinator. To increase sustainability, routine biannual ITAG meetings chaired by government leaders or other in-country organizations, and greater involvement of national public, private, and civil society organizations might support greater political, technical, and financial support for SIVESNU and use of the data among a broader base of partners with similar interests, priorities, and information needs. With a dependency on funding from US government agencies, SIVESNU is at risk if US government priorities or policies change, such as happened with the Northern Triangle funding restriction affecting Guatemala, Honduras, and El Salvador, and which prevented the planned 2019/20 SIVESNU data collection cycle from occurring and delayed the completion of multiple biomarker analyses from previous cycles.

Efforts continue to improve the SIVESNU while maintaining a high-quality, low-cost, timely system. To understand if the precision of young child stunting estimates could be improved with a larger sample, in the 2018/19 cycle all children aged <5 y had anthropometry measured instead of only the single randomly selected child per household. Examining the stunting prevalence results [all children ($n = 1158$) = 46.5%; 95% CI: 40.6%, 52.4%; crude intraclass correlation (ICC) = 0.28, compared with randomly selected single child ($n = 810$) = 41.7%; 95% CI: 35.7%, 47.7%; ICC = 0.19], we determined the larger sample of all children per household was not more desirable because of the higher ICC, similarly wide 95% CI, and low precision (9). With the current sample size used to design SIVESNU 2013 and followed thereafter through the 2018/19 cycle, the sample size can identify a change of 9.6 percentage points in stunting year to year, whereas the trends are useful for monitoring indicators over time and cycles of data can be combined for additional analyses and to identify smaller changes in the prevalence of stunting and other indicators. However, it is important to note that the child sample sizes have never been achieved and some clusters refused to participate each cycle, so decisions moving forward are to revisit the number of clusters, households, and sampling strategies to improve the ability to achieve the child sample size calculations.

Having a small number of highly trained teams and well-established supervisory mechanisms to monitor quality control criteria is key to collecting high-quality data. Quality control activities are integrated into the regular day-to-day field operation, through supervisors, and by periodic visits from INCAP's staff and other monitors, and Epi Info programming. Routinely collecting SIVESNU cycles on an approximately annual basis also supported high-quality data because many field team staff were retained over cycles maintaining their skill and expertise, which is a challenge when there are long delays (e.g., 5–8 y) between data collection cycles for complex surveys.

Waiting on laboratory analysis funding and results caused delays in finalizing reports and limited the timeliness of data disseminations. SIVESNU 2013, 2015, and 2016 were published as single large reports, but starting with the 2017/18 cycle the SIVESNU reports were finalized as modules as soon as results not dependent on laboratory analyses were available (e.g., 2018/19 Module 1 includes the full SIVESNU methods and household level data; Module 2 includes results for

children aged 0–59 mo; Module 3 includes results for WRA; Module 4 all laboratory results). Any laboratory results that were available were included in population-specific modules so they could be disseminated as soon as possible and would then be included again in the laboratory results module for completeness. Furthermore, the SIVESNU report title structure changed to reflect the start and end of data collection, which usually occurs over 2 calendar years, instead of only including the year data collection started. This allowed users to better understand the duration of fieldwork and when to expect reports.

Despite training government staff in SIVESNU data management and analysis, these components have not been institutionalized and reports were delayed. To resolve this issue, INCAP hired a dedicated data analyst consultant whom CDC trained to perform data analyses; report modules have since been finalized in a timely manner, except for some laboratory analyses that were pending due to US government Northern Triangle funding restrictions, and are now being analyzed.

Conclusion

In conclusion, the SIVESNU surveillance platform is a critical tool for government and partners, addresses key data gaps, and provides high-quality data used to monitor and improve public health in Guatemala. Timeliness of data analyses and dissemination of data were strengthened by responsive changes to procedures. The stability of the core technical team and many of the field staff over multiple SIVESNU cycles, as well as the careful planning, training, and supervision of each cycle, were strengths that supported a flexible surveillance system design that typically underwent some revision each cycle. Planning is underway to revise the SIVESNU 2022/23 design to achieve a higher young child sample size. There are also opportunities to consider additional population groups (e.g., men to characterize chronic disease), as well as other content and indicators to continue to assess all forms of malnutrition. Sustainability could be increased with an enabling government environment, strengthening surveillance capacity to implement SIVESNU and use data for decision-making, diversifying financial support, and involving multiple agencies with a mandate to conduct public health surveillance or to use the results as part of the ITAG—all of which takes time to establish and maintain and should not be underestimated. Although no single data information system can meet all data needs, the SIVESNU system can be a useful model for other countries to consider and learn about.

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Data Availability

Datasets described in the manuscript and SIVESNU reports for 2013, 2015, 2016, 2017/18, and 2018/19 cycles are available at: https://www.siinsan.gob.gt/siinsan/monitoreo-y-evaluacion/#.

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