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Style Guide: An Interdisciplinary Communication Tool to Support the Process of Generating Tailored Infographics From Electronic Health Data Using EnTICE3

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Innovation: The style guide supports the communication of complex design specifications in a highly structured format that is nevertheless flexible enough to accommodate project growth. Unlike the typical corporate style guide that has a more narrative format, our style guide is innovative in its use of consistent fields across multiple, standalone entries.

Credibility: The process of populating the style guide prompted the designer toward greater design efficiency and led to consistent and specific instructions that met the framework architect's stated information needs.

Discussion and Conclusion: The guiding values in the creation of the style guide were consistency, clarity, and flexibility. It serves as a durable reference to the desired look and functionality of the final infographic product without dictating an implementation strategy. The style guide format can be adapted to meet the communication needs of other interdisciplinary teams facing a semantic gap.

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Style Guide: An Interdisciplinary Communication Tool to Support the Process of Generating Tailored Infographics From Electronic Health Data Using EnTICE[3]

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Introduction and Purpose

For the Washington Heights/Inwood Informatics Infrastructure for Comparative Effectiveness Research (WICER) project, we compiled survey data from >5,800 primarily Latino members of a northern Manhattan community. Survey variables included anthropometric measures (e.g., blood pressure, waist circumference, height, weight), health behaviors (e.g., physical activity, nutrition), self-reported outcomes (e.g., depression and anxiety symptoms, sleep quality, chronic stress, overall health), and health literacy and numeracy. In an effort to return these survey data to participants in an easily comprehensible and actionable format, we created infographics for the variables collected.[1] Eventually, participants will be able to log in to a community-facing online health portal to view infographics that have been individually tailored to the participants using their WICER data.

Infographics are graphical displays of information, such as charts or diagrams, supplemented with text. Infographics are tailored if they have been customized according to characteristics specific to the intended viewer.[2] We used an iterative participatory design process in which prototype infographics were refined based on

feedback from WICER participants. The tailored infographics are intended to promote community health and effective self-management by supporting community members' comprehension of their personal health information. Patient reported outcomes and other health data can be converted into health communication and community engagement tools. As health communication tools, tailored infographics can facilitate conversation between patients and clinicians. As community engagement tools, they have the potential to help to build a strong fabric of trust with the community when its members see the data they contributed become products useful for health self-management. Examples of infographic formats are shown in Figure 1.

The generation of thousands of infographics containing protected health information (PHI) necessitates secure automation, which we achieve using a novel, adaptable, reusable, and generalizable software approach—Electronic Tailored Infographics for Community Engagement, Education, and Empowerment (EnTICE[3]).[3] EnTICE[3] utilizes a web service application programming interface (API) to perform two major functions: gatekeeping and infographic assembly (see Figure 2). Gatekeeping functions are shown in

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the dark gray box (Figure 2): EnTICE[3] verifies the user's identity, controls access to the survey data, and audits activity. To assemble infographics, EnTICE[3] queries the survey database for the necessary metadata, individual data, and population data. Those data are then used to arrange the graphical components in its repository into an infographic tailored to the user according to graphic design specifications. In Figure 3, a sample infographic has been marked up to show the data sources necessary to generate the various parts of a tailored infographic. The EnTICE[3] approach builds upon the Data Driven Document repository (D3.js), a programming code library that uses digital data to create and control dynamic and interactive graphical forms in web browsers.[4,5]

A high degree of communication and collaboration was required between the lead infographic designer and the framework architect in order to convert correctly the infographic design specifications into the EnTICE[3] computer code that assembles the graphical components. Their professional vocabularies

have little overlap; thus they were faced with a "semantic gap" in communication. In the presence of a semantic gap, differing core assumptions and terminology definitions can substantially hinder communication. The semantic gap between domain and programming experts has been well documented in general and in health care, and has been addressed through a number of structured communication approaches. For example, there are tools that domain experts can use to author rules for decision support systems in natural rather than computer language with subsequent automated transformation for processing.[6,7,8] The Unified Modeling Language (UML) is another approach in which visualizations (e.g., activity diagrams) are explained through structured communication and transformed into computer code. This approach has been used extensively to facilitate communication between domain and technical experts to develop Health Level Seven (HL7) standards for interoperability (transfer of data between information systems)[9] and to develop a model of shared understanding of the clinical research semantics.[10]

Figure 1. Four Examples of Infographic Formats Specified in the Style Guide

Body Mass Index (BMI)
kg/m²

| Underweight | Normal | Overweight | Obese |

27.3

Body Mass Index (BMI) uses your height and weight to estimate how much body fat you have.

Days feeling worried, tense, or anxious in the last 30 days

5

You
5 days

7

Other men in your age group
7 days

Depression Symptoms A

You
Low

Other women in your age group
Moderate

Health Compared to Ideal

Physical Activity · Overall Health · Mental Health · Fruit & Vegetable Consumption
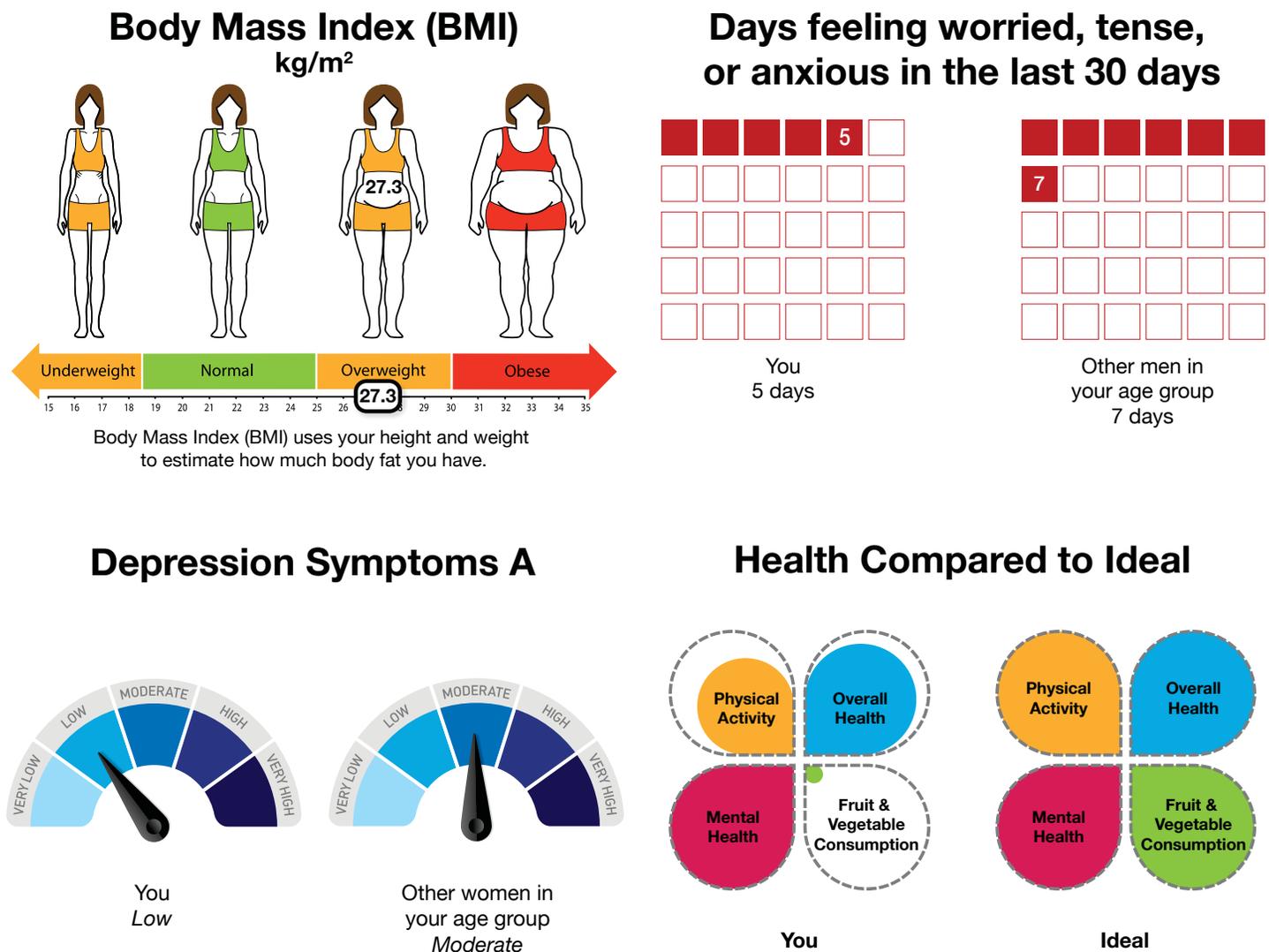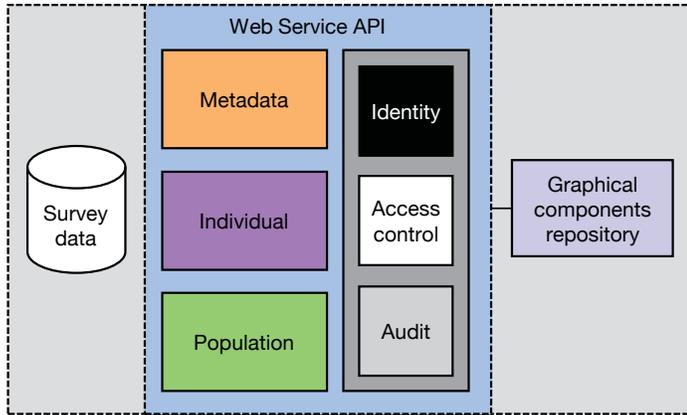
You

Ideal

Figure 2. The EnTICE³ Framework

Given the visual, rather than textual, nature of the structured communication required to produce the design specifications for EnTICE³, another approach was needed. In order to support this visualization automation effort, we created a structured communication tool—a style guide—in which the design specifications were recorded. The principal users of the style guide are a nurse scientist with a background in artistic design (the lead infographic designer) and a software developer (the framework architect). The purpose of this case study is to describe key features of the style guide and to propose use of such a tool for other teams facing a semantic gap or engaged in similar projects.

Design Process
In meetings between the lead infographic designer and the framework architect, it became clear that each infographic had numerous unique attributes to be operationalized into formal computational processes. The two parties collaborated to identify which components of each infographic would be dynamic, as well as the

various framework architecture strategies that could be employed to automatically generate each dynamic component. Particular attention was paid to strategies flexible enough to display very low, very high, and nonmissing zero values. The meetings also served to familiarize the framework architect with the most current design iterations and to identify his information needs. To achieve high-quality communication, detailed written documentation was deemed more practical than frequent, informal in-person consultation. Based on the framework architect's questions and stated information needs, the lead infographic designer identified the attributes that were common across infographics and could thus serve as the organizing structure for the design specifications.

The designer's prior exposure to corporate marketing and branding practices prompted the borrowing of the term "style guide." Organizations employ style guides primarily to promote consistency in visual identity and textual voice. Interested readers can conduct an online search for "style guide" to see many excellent examples.

Style Guide Features
The style guide document comprises two sections: the front matter (i.e., introductory pages), and the infographic entries. The front matter includes a table of contents, a notation of the default font, and a table of the standardized codes that uniquely identify the colors in the graphics. Each of the 23 infographics has its own two-page entry that appears on facing pages when the style guide is printed and bound along the left margin (see Figure 4). Each entry has up to 11 fields that are the organizing structure for the design specifications. See Table 1 for descriptions of the 11 fields and examples how the fields are populated. The lead infographic designer populated the fields for each entry with concise, specific information that uniquely describes the attributes of each infographic in order to provide the framework architect with a ready reference of infographic design specifications.

Figure 3. A Sample Infographic Annotated with Data Sources and Color Coded to Figure 2
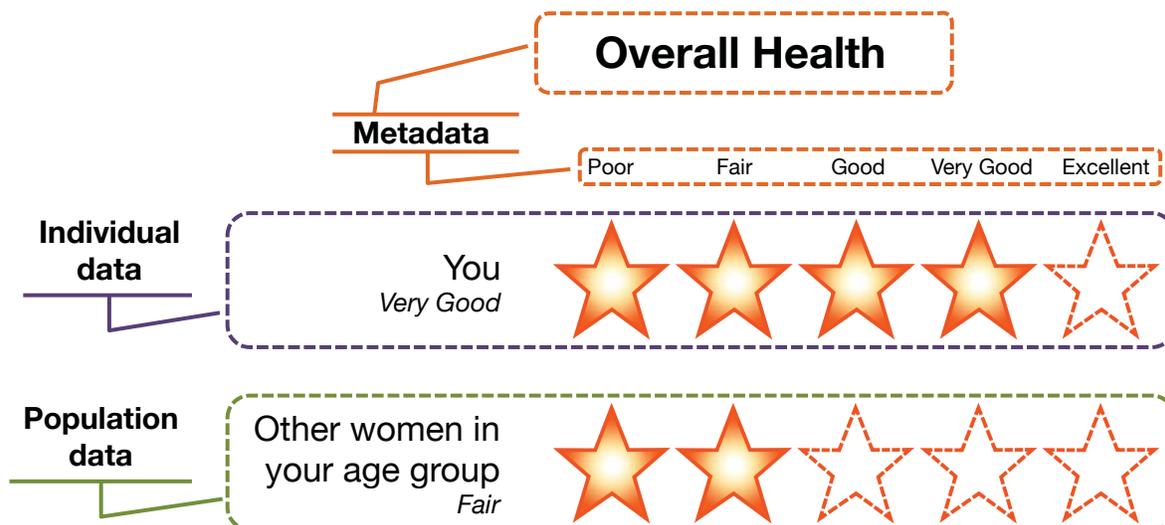
Table 1. Style Guide Fields, Descriptions of the Fields, and Examples of How the Fields Are Populated

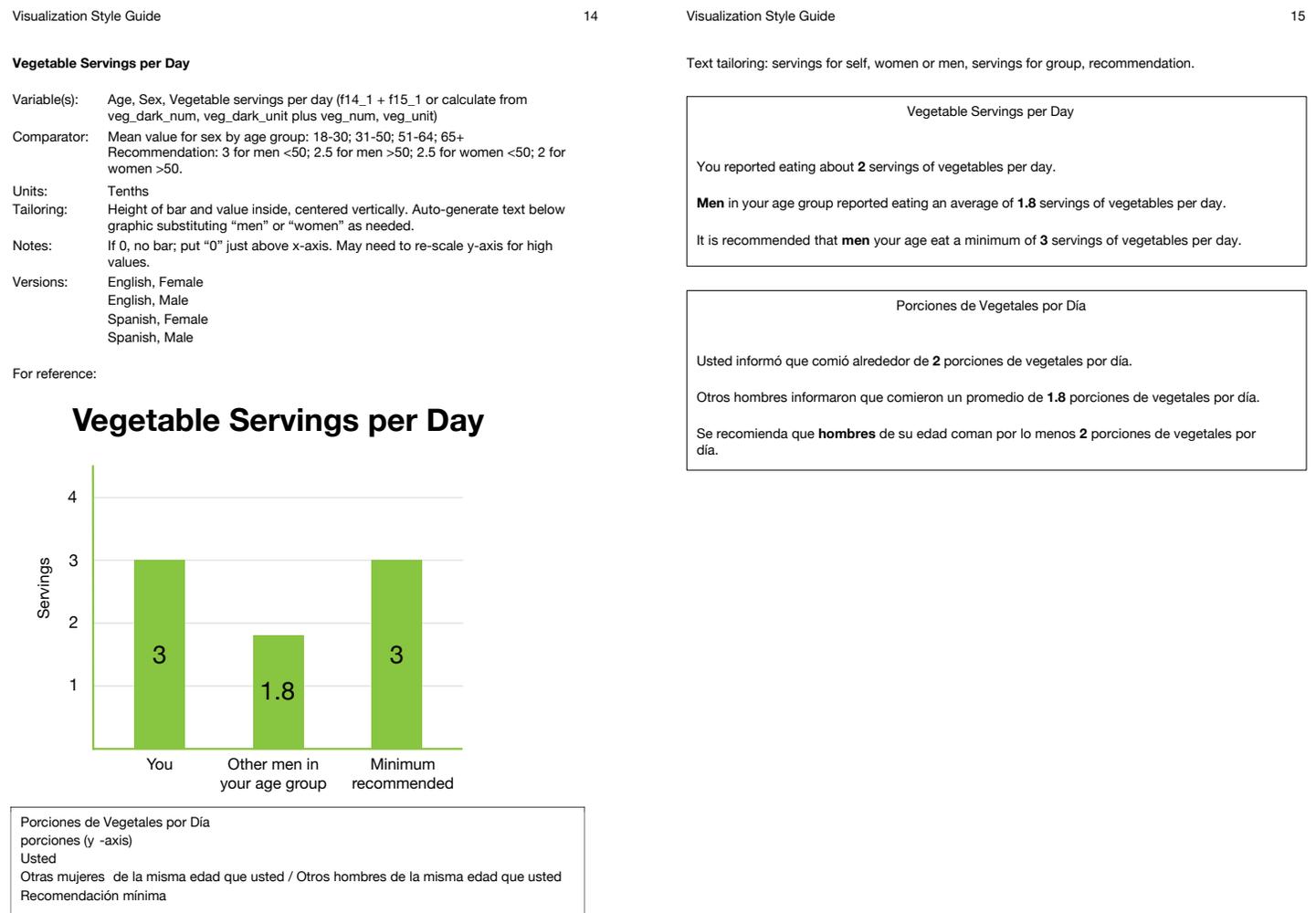| Field Name	Description	Examples
1. Variables	The descriptive names of the survey variables needed to create the infographic and the variable names as they appear in the database, if these differ. Generally, variables continued to be defined as they had been when the survey data were collected, but in some instances, a new variable was needed. New variables were transformations of existing variables (e.g., continuous to categorical, composite of two or more variables).	• Systolic blood pressure (bpsys_davg), Diastolic blood pressure (bpdia_davg) • BMI category (create a new variable based on ranges provided under *Criteria*) • Physical Activity (create a new variable based on instructions in *Units*)
2. Comparators	Comparators are recommendations and mean values for other WICER participants as matched by gender and age group. This field applies to many, but not all, of the infographics. Age groups are defined in this field.	• Fruit Servings Recommendation: 2 for men; 2 for women 18–30; 1.5 for women >30 • Average number of anxious days reported by gender and age group: 18–30; 31–50; 51–64; 65+
3. Units	The unit of measure to be displayed in the infographic. Rules for transformation from numerical values to categories as well as instructions for the creation of composite variables are provided here.	• Whole numbers rounded to the nearest 5 (minutes of moderate exercise per week) • Tenths (vegetable servings per day) • Underweight, normal, overweight, or obese (BMI categories) • Physical Activity. Calculate adjusted exercise minutes: moderate minutes + 2(vigorous minutes). Full clover leaf petal if adjusted minutes > 150; middle petal if 75 < adj. min < 150. Small petal if 0 < adj. min < 75min. Tiny petal if zero.
4. Tailoring	The dynamic aspects of each infographic are specified in this field.	• Height of a bar on a chart • Position of an indicator box on a number line • Adjustments to labeling based on gender
5. Criteria	This field applies only to infographics that referenced body mass index, waist circumference, and blood pressure. Standard Centers for Disease Control and Prevention reference ranges are provided.	• BMI: <18.5 is underweight; 18.5-24.9 normal; 25-29.9 overweight; >30.0 obese
6. Versions	All infographics have at least two language versions. Additionally, some differ by gender as well and thus have four versions.	• English; Spanish • English, Female; English, Male; Spanish, Female; Spanish, Male
7. Notes	This field includes miscellaneous instructions for how to treat very high, very low, and nonmissing zero values.	• If 0, no fill; put "0" in the first box in red font (anxious days) • If 0, no bar; put "0" just above x-axis. May need to rescale y-axis for high values (vegetable servings)
8. Sample Images for Reference	Typically, one sample image is provided; two samples are given for infographics that vary according to gender.	See Figures 1 and 4.
9. Spanish Translations	A text box below the sample image contains the official translation of all text that might appear in the infographic. Word choice is standardized across infographics.	See Figure 4.
10. Text-only Versions	In order to assess whether or not the infographics support comprehension and perceived ease of comprehension, we designed an experimental protocol in which the infographics are compared to text-only versions. The text was composed according to two principles: it should be as easy to read as possible for individuals with low literacy, and it should accurately reflect all the relevant information provided in the infographic. Like the infographics, the text-only versions must be generated automatically. The official text-only versions, English and Spanish, are shown in text boxes on the second (facing) page. Bolded text indicates the words and numbers subject to tailoring. These will not be bolded in the final product.	• Days feeling worried, tense, or anxious in the last 30 days. You reported feeling worried, tense, or anxious for 5 out of 30 days. **Men** in your age group reported being worried, tense, or anxious for an average of 7 out of 30 days. ------------------------- Días entre los últimos 30 días sintiéndose **preocupado**, **ansioso**, o **tenso**. Usted informó que se sintió preocupado, **ansioso**, o **tenso** durante 5 de 30 días. Otros hombres de la misma edad que usted informaron que se sintieron **preocupados**, **ansiosos**, o **tensos** durante un promedio de **7** de 30 días.
11. Text Tailoring	This field is used to specify which components of the *Text-only Versions* are dynamic. Typically, these are the same as those in the infographic—but for some text descriptions, additional notes are given for the Spanish version if words change based on gender or number.	• Number of anxious days for self, women or men, number of days for group. In Spanish, select preocupado/a, ansioso/a, or tenso/a as appropriate for gender and singular or plural for self vs. group.

Although the style guide served as documentation of the design specifications, its more important function was as a structured communication tool. To that end, the guiding values in its creation were consistency, clarity, and flexibility. Consistency was applied to format and layout throughout the document, as well as to naming conventions, fonts, colors, and word choice. Clarity was promoted primarily through the use of concise, precise descriptions. Given that some infographics are similar in either appearance or title, the use of unique names supported clarity. The style guide needed to be flexible enough to remain useful even if infographics are eventually modified, added, or removed. For that reason, cross-referencing between style guide entries was avoided; each set of facing pages is meant to stand independently. The existing fields are general enough to be broadly applicable and can be left blank if not needed; additional fields can be added if and when they become necessary.

Discussion

The style guide facilitated communication between the lead infographic designer and the framework architect by organizing, into a consistent and structured format, all the information that was

necessary for programming. The typical corporate style guide has a more narrative, guideline-based format marked by design jargon (e.g., "Be sure to maintain clear space around the wordmark and the positioning line so that they are clearly legible"). Our style guide is innovative in its use of consistent fields across multiple, standalone entries to facilitate communication across disciplines. The modular template structure of the style guide makes it easier to make changes to the collection of infographics. Designs are easily modified, added, or removed. For example, if our future work with infographics leads us to add animation or interactivity, the addition of one or two fields may be all that is needed to accommodate the added complexity. The adaptability of the style guide in this respect contributes to the long-term sustainability of the project. One of the unexpected benefits of the style guide development process was that it pushed the designer to think systematically about how each graphic would be operationalized. In a few cases, this led to small design changes that had no real effect on the message of the infographic but streamlined the number of dynamic components. The act of populating the fields for each infographic also challenged the designer to anticipate atypical use cases, especially with respect to very high and very low values,

Figure 4. Facing Pages in the Style Guide for the "Vegetable Servings per Day" Infographic

Visualization Style Guide   14

Vegetable Servings per Day

Variable(s):	Age, Sex, Vegetable servings per day (f14_1 + f15_1 or calculate from veg_dark_num, veg_dark_unit plus veg_num, veg_unit)
Comparator:	Mean value for sex by age group: 18-30; 31-50; 51-64; 65+ Recommendation: 3 for men <50; 2.5 for men >50; 2.5 for women <50; 2 for women >50.
Units:	Tenths
Tailoring:	Height of bar and value inside, centered vertically. Auto-generate text below graphic substituting "men" or "women" as needed.
Notes:	If 0, no bar; put "0" just above x-axis. May need to re-scale y-axis for high values.
Versions:	English, Female
	English, Male
	Spanish, Female
	Spanish, Male

For reference:

Vegetable Servings per Day

Porciones de Vegetales por Día
porciones (y -axis)
Usted
Otras mujeres de la misma edad que usted / Otros hombres de la misma edad que usted
Recomendación mínima

Visualization Style Guide   15

Text tailoring: servings for self, women or men, servings for group, recommendation.

Vegetable Servings per Day

You reported eating about **2** servings of vegetables per day.

Men in your age group reported eating an average of **1.8** servings of vegetables per day.

It is recommended that **men** your age eat a minimum of **3** servings of vegetables per day.

Porciones de Vegetales por Día

Usted informó que comió alrededor de **2** porciones de vegetales por día.

Otros hombres informaron que comieron un promedio de **1.8** porciones de vegetales por día.

Se recomienda que **hombres** de su edad coman por lo menos **2** porciones de vegetales por día.

and to plan for them accordingly. For the framework architect, the intended benefit is that the style guide serves as a durable reference to the desired look and functionality of the final product without dictating an implementation strategy.

The style guide offers distinct advantages over both UML and natural language communication approaches to closing the semantic gap. In a UML approach, the programmer and domain expert typically adopt a third, shared language and work synchronously. The added burden of learning an additional language is a clear disadvantage of the UML approach. The style guide allows for asynchronous work and requires that team members have a shared understanding of only a handful of terms (i.e., how the fields used in the guide are defined). Interdisciplinary teams employing a natural language approach may not share all of the same core assumptions about the meanings of specific terms, concepts, or processes. As such, a team can appear to agree on a work plan only to discover later that the various team members had substantially different conceptions of the plan. The style guide format pushes domain experts toward spelling out their intentions explicitly and can thus help circumvent overreliance on assumptions. Furthermore, a highly detailed record of design specifications can support the continuity of a project in the event of personnel changes.

Our experience thus far with the style guide leads us to recommend the use of a similar structured communication tool to other teams engaged in similar work. We believe that it supports interdisciplinary collaboration and promotes consistency and specificity across the final product. The style guide format is applicable to a wide range of projects because the fields provide a framework for recording design specifications that emphasizes the necessary ingredients and the appearance of the finished product, rather than the implementation steps. The framework is applicable whether or not the data depicted are categorical or continuous, publicly available or PHI, individual or aggregate. One key limitation of the style guide is that the specific format we used may not meet all the needs of other projects. Adaptations to the style guide, such as addition or modification of fields, may be enough to broaden the utility of the tool for a larger range of projects. For example, our current set of infographics depicts only cross-sectional data. Depicting longitudinal data would require an additional field to specify the time points to be shown.

Also, we specified a font and color palette in the front matter because these were the same across the infographics. A team wishing to have more varied infographics might move that information out of the front matter and into the individual entries by adding *Colors* and *Fonts* as fields. We anticipate that adherence to the values of consistency, clarity, and flexibility will help to maximize success. The essential, adaptable components of the style guide are the following: (1) standalone entries that avoid cross-referencing; (2) a consistent set of fields to capture all relevant design specifications; and (3) population with concise, specific information. This last component highlights the other key limitation to the style guide: that it is only as good as the quality of the input. In other words, the utility of the tool depends heavily on the detailed dili-gence of the person who completes it. In our experience, though, the format itself promotes comprehensive reporting of design specifications.

Conclusions

The style guide is a fluid document that will continue to evolve as our project matures. Ongoing subjective evaluation of the style guide will inform future refinements. Evaluation is focused on noting any areas of impaired communication that arise (pain points) in the transformation of the specifications into software code and on the level of congruence between design prototypes and final products.

Tailored infographics contribute to a learning health system by adding value to existing data streams. To that end, our intent is to make EnTICE[3] publicly available when the build is complete; the mechanism for distribution is still to be determined. Also pending is a time frame for disseminating the infographics to WICER participants via a community health portal. We are exploring options for implementation that allow participants to view their PHI and that also meet the data security and Health Insurance Portability and Accountability Act (HIPAA)-compliance standards of the NewYork-Presbyterian/Columbia University Medical Center. At present, we offer our style guide and infographics for use and extension by others; requests for these should be directed to the first author.

Acknowledgements

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