REVIEW

Food and Nutrition Systems Dashboards: A Systematic Review

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ABSTRACT

The rapid expansion of food and nutrition information requires new ways of data sharing and dissemination. Interactive platforms integrating data portals and visualization dashboards have been effectively utilized to describe, monitor, and track information related to food and nutrition; however, a comprehensive evaluation of emerging interactive systems is lacking. We conducted a systematic review on publicly available dashboards using a set of 48 evaluation metrics for data integrity, completeness, granularity, visualization quality, and interactivity based on 4 major principles: evidence, efficiency, emphasis, and ethics. We evaluated 13 dashboards, summarized their characteristics, strengths, and limitations, and provided guidelines for developing nutrition dashboards. We applied mixed effects models to summarize evaluation results adjusted for interrater variability. The proposed metrics and evaluation principles help to improve data standardization and harmonization, dashboard performance and usability, broaden information and knowledge sharing among researchers, practitioners, and decision makers in the field of food and nutrition, and accelerate data literacy and communication. *Adv Nutr* 2022;13:748–757.

Statement of Significance: This review proposes 48 evaluation metrics for nutrition and food dashboards and evaluates publicly available nutrition data dashboards using quality metrics. This review also makes recommendations to improve sharing, exchanging, and analyzing nutrition and health data.

Keywords: nutrition and food surveillance, nutrition data quality, data visualization, quality metrics, dashboard evaluation

Introduction

Nutrition surveillance is defined as a strategy or system to monitor food and nutritional status and diet-related disease prevalence among populations, which informs policy planning and leads to improvements in nutrition at the population level (1, 2). Intensive research and assessment in the fields of food and nutrition have generated and continue to generate large volumes of data. The traditional data sources such as large-scale prospective national cohorts, household surveys, and administrative records (2, 3) are now expanded by satellite imagery, drone-based technology, and personalized nutrition data generated by wearable devices, pushing nutrition surveillance to further embrace digital transformation. In the last decade, the number of interactive dashboards developed to monitor and predict nutritional status in populations has increased, including, for example, the Food Systems Dashboard (4) developed by Johns Hopkins University and the Global Alliance for Improved Nutrition and the Hunger Map Live dashboard (5), produced by the World Food Programme. Yet understanding the utility and usability of food and nutrition systems dashboards remains limited (6).

Prior evaluations of these platforms typically applied generic parameters such as the nutrition data scope, data

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Abbreviations used: ADA, Americans with Disabilities Act; ICC, intraclass correlation; SEO, Search Engine Optimization.

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quality, visualization capability, and dissemination ability (7, 8). One systematic review by Wu et al. noted the importance of using commonly reported metrics that can be modified or adapted for the specific context of the conducted research (9). However, considering the wide spectrum of nutrition-related disciplines and inconsistent, ever-changing data collection protocols, nutrition dashboards are difficult to evaluate with a general metric. The creation of standardized metrics for data dashboards is further complicated by complex perceptual and cognitive reasoning processes involved in evaluating data visualizations (10). Thus, we need a set of well-grounded principles and metrics to examine and evaluate the quality of dashboards and their visualization tools. In our early work in creating visualization tools for a broad audience, we developed a set of rules for designing efficient scientific graphical displays using 4 major principles: evidence, efficiency, emphasis, and ethics (4Es) (11). In brief:

- Evidence relies on the content, results, or concepts that correspond to the information the graph conveys, and the content, results, or concepts are transferrable to a verbal description.
- Efficiency states that a graph should help to explain the results or concepts by taking advantage of visual perception and utilize high standards of readability, interpretability, and clarity.
- Emphasis states that a graph should be user-friendly, force the intended audience to note the unexpected, motivate questions, and clarify statements.
- Ethics involves achieving the truth and promoting essential values such as accuracy, precision, reliability, integrity, and inclusiveness at neither excess nor deficiency, but at the mean of these two.

These principles are adaptable beyond individual visualizations and can be applied broadly to evaluate interactive platforms integrating data portals and visualization dashboards utilized to describe, monitor, and track records temporally and spatially (12–17).

The objectives of this article are to conduct a systematic review of the existing food and nutrition systems dashboards and characterize dashboards based on specially designed evaluation metrics from the external user perspective. We built evaluation metrics using the suggested principles and standard metrics for assessing functions features of modern dashboards, in order to evaluate dashboards which mainly communicate their content visually (12–17). Constructing well-defined evaluation metrics in the context of nutrition surveillance is an essential step in data standardization and harmonization. We expect that such metrics can form reference benchmarks for further data sharing and exchange among researchers, practitioners, policy and decision makers, improve dashboard performance, build trust, and accelerate data literacy and nutrition and health communication.

TABLE 1 Three sets of search terms and keywords

Set 1	Set 2	Set 3
Nutrition	Dashboard	Surveillance
Nutritional	Data visualization tool	Monitor
Dietary	Data visualization platform	Health
Food	Atlas	Population health
Malnutrition	Database	—
Hunger	—	—

Methods

Search and selection strategy

For this study, we defined a food and nutrition system data dashboard (referred to as a nutrition dashboard thereafter) as a web-based platform that presents nutritional data by using interactive visualization tools such as maps and graphs (distinct from a nutrition database offering data exchange, or a nutrition infographic offering static data or information visualization). We defined a platform "accessible" when we could discover a web-based dashboard in a public domain with or without registration or creating an account requiring the provision of personal information.

We defined the following exclusion criteria:

- Majority of the content in a dashboard is not related to nutrition, food, or health data.
- Data and information are not translated into graphs or maps.
- Dashboards lack user interaction: users can't interact with or customize the visualization and tabular data.
- Dashboards are not publicly accessible.
- Dashboards are duplicated.

We performed a search of PubMed, Google, and Google Scholar (February 2021) with the primary keywords "Nutrition" and "Dashboard," the subsidiary keyword "Health" and related analogies to form 3 main search sets (see **Table 1**).

After conducting a detailed screening of 33 identified dashboards, 20 were excluded due to low relevance to nutrition ($n = 10$), no user interaction possible ($n = 8$), no link to an active dashboard platform ($n = 1$), and duplication of a dashboard under a different name ($n = 1$). We report findings on 13 unique dashboards that met our inclusion and exclusion criteria (**Supplemental Table 1**).

Assessment metrics

For each selected dashboard we extracted dashboard names, links, their food and nutrition content, goals, host organization, visualization tools, targeted audience, availability of tabular data, and time last updated. We then created a set of evaluation metrics to assess the functionality and operation features of modern dashboards (12–17). The proposed metrics included the components referring to general guidelines and standards of dashboard design, data sources and quality, visualization quality, and a customized assessment of information relevant to nutrition and health. The metrics are organized and aligned with the principles of the 4Es: evidence, efficiency, emphasis, and ethics as described below (**Table 2**).

Evidence principle.

The evidence principle serves as the foundation for evaluating the validity of the content and data sources that support a dashboard. This principle requires dashboards to meet a high standard of data quality and integrity, which in turn depends on data standardization, granularity, and completeness to ensure dashboard reliability.

Metrics on dashboard goals and content scope reflect the presence and clarity of the nutrition dashboard overview to help external users recognize dashboard capacity and usability. General goals define what information a dashboard intends to provide, how a dashboard clarifies its design and functionality, and how a dashboard illustrates, explains, and justifies covered issues. The content scope of a dashboard clarifies the potential use of data and data sources, which ensures that a dashboard assigns and maps data precisely according to its main goals and objectives.

Data quality indicators refer to data integrity, data standardization, data granularity, and data completeness, which are essential for a reliable dashboard. Data integrity indicates whether a dashboard provides clarifying information on data sources, collection methods, and representativeness. Data standardization aims to bring data to a standard format (when possible), including the unit of measurement. Temporal and spatial resolutions are the critical requisites needed to ensure data comparability across time periods and geographic locations. Data granularity applies to the potential levels of detail, such as aggregation levels in demographic characteristics, time, location, and nutritional contents. Data completeness covers the extent and pattern of missing data, including its justification and presentation.

Efficiency principle.

The efficiency principle focuses on the content organization and visual properties of a dashboard. This includes taking full advantage of the power of visual perceptions in presenting data so that users can navigate a dashboard according to their needs and interest. The indicators of efficiency are made up of platform capability and visualization quality.

Platform capability measures the ease of finding a particular dataset and presenting it in a user's requested format. Nutrition dashboards often create data portals, where the processes of searching, reviewing, downloading, and updating data are flexible yet sophisticated. Visualization quality ensures the efficiency of a dashboard, which includes readability and interactivity. Clear titles, labels, color schemes, and resolutions are all needed when creating visualizations. Embedded descriptions and guidance text should further enhance the visual's readability. Interactivity, either through manual controls, drop-down menus, or slider functions, aims to customize the visualization according to users' needs. These functions also help highlight secondary data and compactly show numerous visualizations without overwhelming users.

Emphasis principle.

The emphasis principle addresses a dashboard's ability to recognize the needs of the target audience and to tailor the content to their perceptions, abilities, and interests. In other words, we evaluate whether a dashboard presents information clearly with sufficiently detailed summaries.

Platform accessibility indicates the ease of finding, navigating, and utilizing data and other information from a dashboard. This includes the availability of supportive materials such as tutorials, reference information, publications. We adopted search engine optimization (SEO) guidelines (13) to measure how the host organization promotes their dashboards on search engines. To evaluate how dashboards allow users to navigate information, we use the Americans with Disabilities Act (ADA) compliance guidelines (17).

We also aimed to assess the target audience's potential comprehension of a dashboard. A dashboard must be well organized to understand its structure and content accurately. This includes the use of storytelling strategies to navigate dashboard content, rational connections across content elements, plots, and embedded texts. We assess the ability for interaction between dashboard designers and the targeted audience through the accessibility to designer contact information to ask questions and provide feedback. We expect that a dashboard host collects reasonable information from users when providing a detailed response or fulfilling a data request.

Ethics principle.

Nutrition dashboards provide information to the public, so ethical norms and best practices should be applied. Disclosing conflicts of interest require that sponsors and contributors are listed for public transparency. We applied ethical guidelines for statistical practice from the American Statistical Association to assess all parties involved in data preparation and presentation.

Rater assignment and analysis

To measure the response to our evaluation metrics and review the performance of nutrition dashboards, we assigned dashboards randomly to 11 internal raters (4 males, 7 females) for evaluation using the proposed evaluation metrics. Raters' domain expertise ranges from nutrition epidemiology, data science, statistics, nutrition communication, and web development (5 raters have a PhD degree, 5 have a master's degree, and 1 has a bachelor's degree) (see **Supplemental Table 2** for raters' and developers' background information). Four raters reviewed all 13 dashboards, and 7 raters reviewed 3–5 dashboards. Each dashboard received 6 ratings for each of the 48 metrics. Each metric utilizes a Likert scale, a psychometric response scale in which responders specify their level of agreement to a statement, with 5 levels of agreement: 1—strongly disagree; 2—disagree; 3—neither agree nor disagree; 4—agree; 5—strongly agree. We assessed the agreement among the raters and accounted for interrater variability in the models. To demonstrate raters' agreement for each dashboard, we calculated intraclass correlation

TABLE 2 Principles, indicators, and metrics for nutrition data and dashboards

Principles	Indicators	Subindicators	Metrics
Evidence	Goals and scope		1. Overall goals are clearly stated
			2. Data offered by the platform support the claimed goals
			3. Data are related to nutrition and diet
			4. A sufficient description and reasonable justification are provided for each indicator/variable
	Data quality	Data integrity	5. All the data are accompanied by a clear description of data sources, links, references, and metadata
			6. The dashboard provides information on population coverage, representativeness, timeframe, and sampling design
			7. The dashboard clarifies data collection methods: surveys, cohorts, census, surveillance, or estimated from statistical models
		Standardization	8. The data can be compared across time, geographical locations, and different indicators
			9. The quantity unit for data in the same category is uniform and provides sufficient information on terms, definitions, units, measurement, and calibration methods
			10. The dashboard clarifies the level of available geospatial aggregations: postal code, village/city/town, state/province/region, and country
			11. The dashboard clarifies the level of available temporal aggregation: day, week, month, quarter, year, etc
		Granularity	12. For a given level of geospatial aggregation, the data can be further divided into geographical subdivisions
			13. For a given level of temporal aggregation, the data can be further divided into temporal subunits
			14. The data are broken down by exhaustive demographical characteristics for an individual (e.g. gender, age, ethnicity, education, etc.)
			15. The data are broken down by exhaustive demographical characteristics for a household
			16. The data are broken down by exhaustive nutrition characteristics such as nutrients, food items, food groups, and diets
		Completeness	17. The amount and proportion of missing data for individual variables, including time and georeferencing, are stated
			18. The proportion of missing data is $<10\%$
			19. Missing data are clearly denoted as missing, NA, none, or not available
			20. Reasons for missingness are clearly stated
Efficiency	Platform capability		21. The dashboard includes a data portal that allows users to access the data
			22. The platform allows users to explore, review, and download selected data in commonly used formats
			23. The dashboard is up to date and has the flexibility to incorporate more data
	Visualization quality	Readability	24. The dashboard provides adequate and effective visualizations to demonstrate the data distribution, time trend, quality, quantity, and relation of the data
			25. The dashboard provides a sufficient description for each visualization with adequate details on the context of the data
			26. The visualizations have clear title, axis labels, data units, and color/marker legends
			27. The visualizations use effective and accessible color schemes and font sizes
			28. The visualizations are available in high resolution
		Interactivity	29. The dashboard includes interactive data visualizations
			30. The dashboard includes drop-down menus with multiple indicators
			31. The dashboard includes drop-down menus with different levels of details
			32. The dashboard includes zoom in/out option
			33. The dashboard includes a visualization download option
			34. The dashboard allows users to manipulate visualizations to accommodate key interests
Emphasis	Platform accessibility		35. The dashboard is within the top results in search engines (e.g. Google, Bing) and follow SEO guidelines (keywords present, text highlightable, fast loading) (13)
			36. The platform is user-friendly and allows users to easily navigate and explore data and visualizations according to ADA website compliance (e.g. text readable, alt-text on hovering over images, headers present) (17)
			37. The dashboard includes a tutorial to walk users through the entire platform (e.g. informative pop-ups, a tutorial video)
			38. The dashboard includes sufficient reference material, publications that related to the topics in the platform, information on the methodologies for building a dashboard and handling the data

(*Continued*)

TABLE 2 (*Continued*)

Principles	Indicators	Subindicators	Metrics
		Comprehension	39. The dashboard visualizations provide appropriate highlights of the text, markers, reference lines, common trends, and patterns
			40. The dashboard has a good storytelling strategy with a clear focus on the main points
			41. There are clear logical flows and connections between visualizations, multipanel plots, and embedded descriptions
			42. The dashboard offers meaningful comparisons between groups, time periods, geographic locations using visualizations
			43. The classification, presenting order, and length for different topics are well balanced
	Contacts and communication		44. The dashboard includes contact information for questions, suggestions, and feedback
			45. The dashboard requests information from users and provides a password-protected working environment
Ethics		Conflicts of interest	46. Funding sources and roles of funders are clearly stated
			47. Roles of all contributors to the dashboard are clearly described
		Responsible conduct	48. The dashboard explicitly highlights responsibilities to the public, funders, research subjects, research team colleagues, and other statisticians or statistics practitioners according to ASA Guidelines (14)

ADA, Americans with Disabilities Act; ASA, American Statistical Association; SEO, Search Engine Optimization.

(ICC), a commonly used statistic for ordinal variables like the Likert scale (18), and the ICC values ranged from 0.61 with 95% CI: 0.41, 0.76 to 0.79 with 95% CI: 0.68, 0.87.

As reviewer scores have a nested design, in which each rater reviewed each dashboard for a set of metrics, the models with a hierarchical variance structure were used to account for heterogeneity. To evaluate metric-specific average scores, we applied a linear mixed effects model with metrics-specific random effects and adjusted for interrater and dashboard-specific variability as fixed effects. This model was also applied at the principle, indicator, and subindicator levels. To evaluate dashboard-specific average scores, we used a linear mixed effects model with dashboard-specific random effects adjusted for raters' variability as fixed effects. All statistical analyses were conducted in R version 3.6.2.

Results

Summary of reviewed nutrition dashboards

The hosts of the 13 examined dashboards represent intergovernmental organizations ($n = 7$), nongovernmental organizations ($n = 2$), and university/research institutes ($n = 4$). Dashboard goals focused on sharing global nutrition data, monitoring and tracking nutritional progress and gaps, and supporting evidence for nutrition programs and policies. The covered topics included nutrition and health, specifically food consumption, breastfeeding, micronutrient deficiency and supplementation, prevalence of overweight, obesity, stunting, and wasting. For example, the Global Fortification Data Exchange dashboard aimed to provide data necessary to track global progress on food fortification and enable decision makers to use data to improve the quality of national fortification programs. The State of Acute Malnutrition dashboard aimed to provide a single platform for co-ordinated data sharing for acute malnutrition, improve the data quality, identify gaps in data, and support improved use of data and evidence for programs and policies for acute malnutrition. All web-based interactive dashboards utilize visualization tools, such as web visuals by front end framework and data platforms like Tableau and Microsoft Power BI, to create, deploy, and share the interactive visualizations. All included dashboards were updated in 2020, except the National Institute of Nutrition Atlas in India, which was last updated in 2017. Detailed information for each dashboard is available in Supplemental Table 1.

Metrics and dashboard evaluation results

Figure 1 reports raters' assessments of dashboard performance according to the 48 evaluation metrics (shown in Table 2). This heatmap reflects the color-coded mean scores from 6 raters for each metric and each of the 13 dashboards. The crude average values for each of the metrics are provided. The average scores adjusted for rater and dashboard variability obtained from the mixed effects models are shown in the last column and under the name for each principle, indicator, and subindicator, accordingly. The adjusted average scores for individual metric ranged

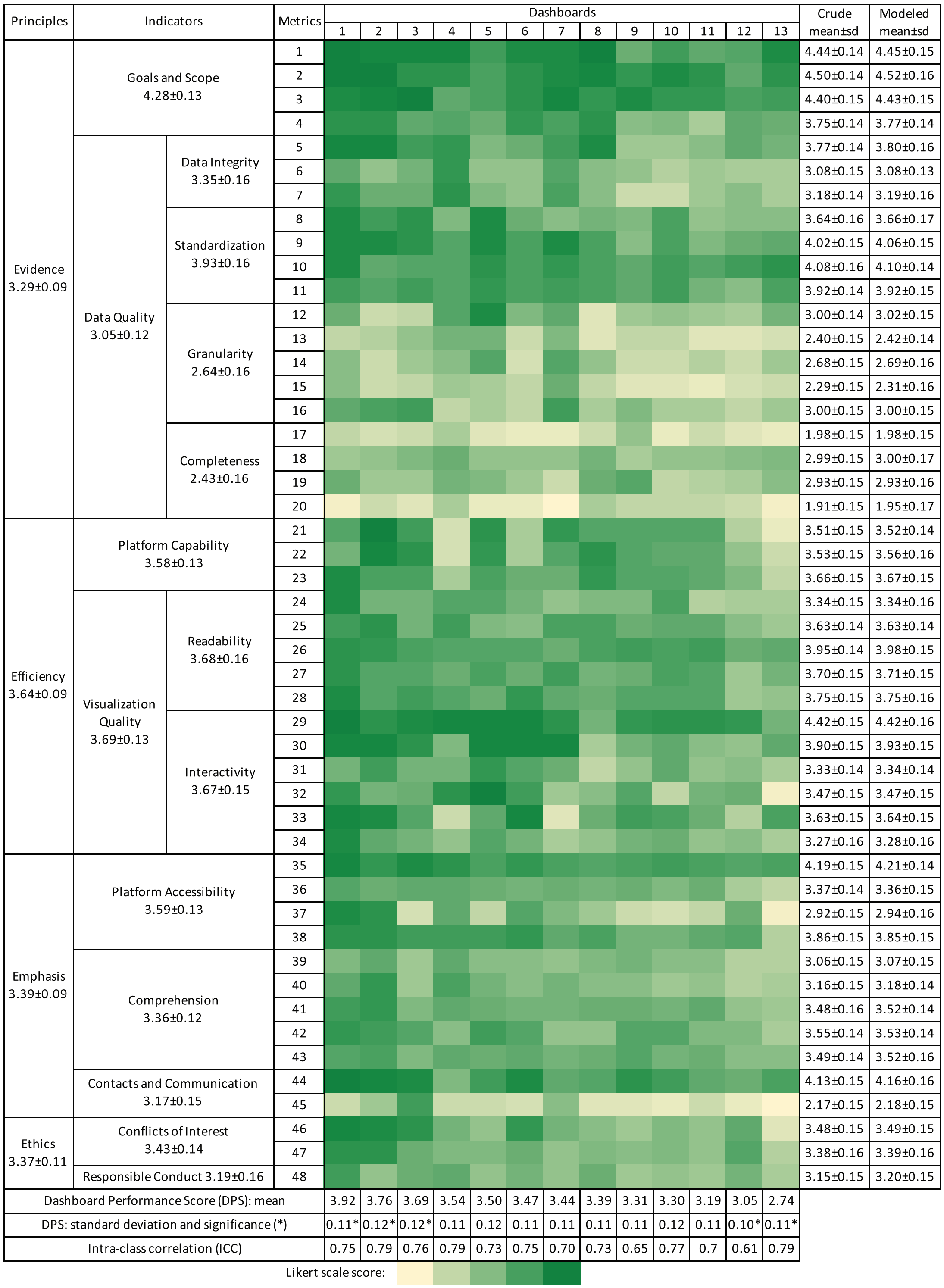

FIGURE 1 A heatmap of dashboards' evaluation results where metrics are arranged by principle, indicator, and subindicator. The metrics are shown in numbers, which are aligned with the metrics order in Table 2. The heatmap represents crude mean scores from 6 raters for each metric and each of the 13 dashboards with light yellow indicating a score of 1 and dark green indicating a score of 5. The crude scores with SD across all dashboards for each metric are shown in the second to last column. The average scores adjusted for rater and dashboard variability obtained from the mixed effects models are shown in the last column and under the name for each principle, indicator, and subindicator, accordingly. Dashboards are listed in descending order of overall performance scores aligned with Supplemental Table 1. The dashboard performance scores with SD adjusted for interrater variability is shown in the third and second to last row, and dashboard scores significantly different from the average score (*P*-value <0.05) are marked with asterisks. Intraclass correlation (ICC) scores for each dashboard are shown in the last row.

from 1.95 ± 0.17 to 4.52 ± 0.16. Overall dashboards' performance scores ranged from 2.74 ± 0.11 to 3.93 ± 0.11, and dashboards with significant differences from the average score are marked in Figure 1.

The adjusted score for the evidence principle was 3.29 ± 0.09, the lowest score among the 4E principles. At the indicator level, the goals and scope had the highest score (4.28 ± 0.13) within the evidence principle and the highest score among all indicators. Within this indicator, metric #2 evaluated whether the platform's data support the goals had the highest score (4.52 ± 0.16). However, the indicator of data completeness and metric #20 evaluating whether the dashboard clearly states reasons for missingness had the lowest scores (2.43 ± 0.16 and 1.95 ± 0.17, respectively).

The adjusted score for the efficiency principle was 3.64 ± 0.09, which was the highest score among the 4E principles. Within the efficiency principle, the indicator of visualization quality had the highest score (3.69 ± 0.13). Metric #29, reflecting interactive data visualizations, scored the highest (4.42 ± 0.16), whereas metric #34, indicating the ability to manipulate visualizations and accommodate key interests, scored the lowest (3.28 ± 0.16).

The adjusted score for the emphasis principle was 3.39 ± 0.09; the indicator of contacts and communication scored the lowest within this principle (3.17 ± 0.15). Metric #45, related to requests for user information and offering a password-protected working environment, had the lowest scores (2.18 ± 0.15). In contrast, metric #44 under the same indicator focusing on contact information for questions, suggestions, and feedback had the highest score (4.16 ± 0.16) across all metrics within the emphasis principle.

The adjusted score for the ethics principle was 3.37 ± 0.11. Metric #46, indicating transparency of the funding sources, had the highest score (3.49 ± 0.15). In contrast, metric #48 indicated responsibilities to the public, funders, research subjects, research team colleagues, and other statisticians or practitioners had the lowest score (3.20 ± 0.15).

Discussion

The rapid development of research and increased demands on data visualizations in nutrition and health domains necessitate the utilization and application of interactive data visualization dashboards. In our study, we created 48 evaluation metrics based on the 4E principles. We reviewed a representative sample of 13 publicly available nutrition dashboards by applying our evaluation metrics. We found that nutrition dashboards have been actively generated and updated by a variety of institutions, including intergovernmental organizations, nongovernmental organizations, and university/research institutes. Our evaluation metrics can reveal a gradient performance and highlight some strengths and limitations of current nutrition dashboards.

Overall, the majority of dashboards clearly stated their goals and scope. Data provided on dashboards were well aligned with their stated goals and closely related to nutrition and health. Dashboards also did well to standardize reported data – units of nutrition and health indicators were consistent across platforms as were the granularity of temporal and geospatial information. All dashboards incorporated interactive visualizations that increased the capacity of data reporting. Drop-down menus were frequently employed, which facilitate increased user engagement and customization of information according to users' needs. Dashboards were also easily accessible within search engines, and many provided contact information to promote communication between dashboard owners and users.

However, evaluation metrics also identified various gaps in dashboard development. Data granularity was rated relatively poorly among the reviewed dashboards as most dashboards provided information at the global or national level. This minimizes the opportunity for more targeted subnational programming and planning by external users. Less spatial granularity may have also inflated data standardization scores, which are more easily achieved with less variability in reported data. Although this limitation could be mainly an underlying issue with data collection, it can also be the dashboard creators' choice as to which levels of data should be presented in the dashboard or how data could be aggregated. We recommend improving nutrition data's spatial, temporal, and demographical granularity at all stages, including data collection planning, programming, and dashboard designing. Our highlight on granular data aligns with essential characteristics reported in the Public Health 3.0 era (15), which emphasizes the importance of data granularity to accommodate the fast-evolutionary changes in epidemiology.

We found that nutrition dashboards rarely reported on this metric including both the proportion of and reason for missing data. We recognize that those factors are difficult to report accurately, especially when a dashboard uses secondary data without a detailed description of the data. However, more awareness must be given to the completeness of a dashboard to ensure the accuracy, precision, generalizability, and repeatability of analyses conducted using these data. Data completeness cannot be fully controlled at the dashboard implementation stage but rather at the level of data collection and verification. However, recognizing the degree of data completeness and understanding the barriers help researchers to grasp the quality of health information and plan the analysis and interpretation accordingly (16). For this reason, we recommend that data completeness should be one of the most clearly displayed metrics when developing a dashboard. This might help to ensure that users reviewing or downloading data acknowledge the limitations of results they generate.

The dashboards invoked different procedures for sharing data including compressing data into a zip file or separating data by different studies, topics, and indicators. Some dashboards allow users to preview data while others even allow users to apply filters to customize and download data according to their interests. Nutrition data visualization dashboards rely on data, which must be redistributed in the most efficient and usable format possible. Integrating a filter feature for data downloads from generated visualizations will boost the efficiency of querying tabular data from dashboards. Some dashboards already require the user's information for the purpose of downloading data, which provides a good example of how dashboards are not simply data repository platforms but communication bridges between data curators and users. Collecting user information and interests further helps to optimize the function, quality, and quantity of available data on dashboards in accordance with users' needs.

The methodology for assessing the quality of data visualizations is actively under review. Experts from various disciplines are examining how various ways of constructing graphs, plots, and maps contribute to their perception, deep learning, and understanding by peer researchers and general audiences. In our work, we emphasized that "A proper graph, if and when translated into a language, should clearly reflect the data and research results without losing details or overemphasizing a point" (11). We further suggested more complex forms of data visualization (19, 20) and argue that visualization is the process of constructing an informative view of the data appropriately grounded in a statistical context (21, 22). The balance of providing a main theme or message while also offering granular information about reported data ensures such an informative view. As visualizations invoke the flow of critical thinking and sensations formed by prior experience, knowledge, and imagination, we should anticipate the flow of intended and nonintended perceptions (12). Sensible consequences of the visual perceptions triggered by selected colors, marker sizes, or graph styles can help the viewer to follow the story or can lead the viewer astray. Besides high-quality graphs, the storytelling strategy and the correct and effective description and interpretation are equally important as they help convey the developer's critical message for the targeted audience. We used guidelines from other disciplines to generate our evaluation metrics and better assess if nutrition dashboards have high accessibility and user-friendliness. For example, SEO guidelines (13) and ADA compliance (17) were taken into consideration in dashboard design to improve dashboard accessibility by emphasizing easier access and navigation. Moreover, ethics guidelines from the American Statistical Association (14) are an important reference when addressing ethical issues in web-based nutrition dashboards. As the establishment of dashboard evaluation metrics is based on a multidisciplinary foundation, the effectiveness of these metrics can be validated in other domains.

Our review has several limitations. Reviews of data dashboard quality are only in their infancy. Few studies have evaluated nutrition dashboards and recommended quality metrics. Manorat et al. have reviewed some global data visualization tools but not specifically for dashboards and no evaluation metrics were mentioned in their discussion (8). Wu et al. have offered 4 recommendations for evaluating visual analytics technologies in the healthcare domain (9). Although those studies provide a foundation for conducting our review, we were unable to validate our results using a gold standard or other references. In future studies, more information should be collected directly from dashboard owners and external users to confirm our evaluation metrics' effectiveness. In the proposed analysis, we prioritized quality over quantity metrics, and omitted metrics reflecting the number of available indicators. Although quantitate metrics are easy to assess they may not be the best measurements. Future development of methods assessing the balance and composition of metrics is warranted. We were only able to review dashboards presenting information in English. Moving forward, we believe that dashboards could have the potential of broader reach if they are suitable for translating into multiple languages. Most importantly in implementing the search, we could not use Boolean operators to make our search reproducible, as there is no standardized data repository to specifically manage dashboards and their metadata. Our work offers the initial benchmark for reviewing nutrition and health dashboards in a systematic and comprehensive manner. We call for a unifying effort of nutrition and public health professionals to create a registry of web-based platforms and dashboards to facilitate reproducible research.

In summary, with the proposed quality metrics we were able to identify the common strengths and challenges of current nutrition dashboards. Though we couldn't judge the exact performance by a simple score, we demonstrated the range in dashboard performances. This study served as an important step to explore the quality of the existing dashboards from an external user's perspective. From our research, we derive several recommendations that can help to improve nutrition and health data dashboards.

- Improve nutrition data usability and develop data reporting best practices that adhere to the 4E principles: evidence, efficiency, emphasis, and ethics.
- Improve the granularity of geographic information at refined spatial levels to ensure equally granular nutrition and health programming and planning by scientists, public health leaders, and policy makers.
- Improve the granularity of temporal information including time-stamped data to better reflect dynamic changes in collected nutrition and health data at regional, state, and local level.
- Ensure reporting of the extent and patterns in data missingness so that data users recognize the quality, accuracy, and reliability of research findings made using data contained in any dashboard. This includes providing clear documentation on the reason for and amount of missing data.
- Promote customization, including preview features and easily adaptable data downloads, so that users can select the complexity and content focus of data while maintaining proper anonymity of reported data.
- Regularly update the review of active dashboards to ensure the timeliness and effectiveness of data use and sharing amidst the rapid volume of nutrition and health research being conducted.
- Form a multidisciplinary team of nutrition professionals, health scientists, and data experts to guide the improvements in dashboard performance and call for

creating a global registry of web-based platforms and dashboards to facilitate reproducible research. This approach will also help to assess the legitimacy and expertise of the host organizations and the diversity of represented viewpoints, expertise, and disciplines.

To empower future research and practice, dashboards could serve as an essential tool enabling deeper understanding of interconnections of nutrition and food with many natural and social systems. The integrated and annotated data repositories should include not only health-related indicators but also those related to various determinants of nutritional status and many aspects of food security and environmental impacts. Thus, the proposed metrics could be expanded to reward the inclusion data streams for nonnutrition-specific indicators that are relevant to food, diets, food system environmental sustainability, community resilience to climate changes, and other pressing topics.

Interactive dashboards, commonly used in business data analytics, are being applied to health and nutrition domains (6, 9, 23). These data management tools track, analyze, monitor, and visually display key metrics while allowing users to interact with data and generate well-informed data-driven decisions. The modern food and nutrition systems dashboards should cover the full cycle from systematic data gathering and processing, proper analysis and interpretation of trends and patterns, delivery of results to inform policy developments and assessment, to confirm existing priorities and setting up new priorities for data collection (2, 24). Like the surveillance systems used for monitoring diseases, the modern dashboards should aim to track the nutritional status in populations and to detect unusual or undesirable trends and patterns in a variety of nutrition indicators. The improvements in precision, accuracy, and credibility of collected food, health, and nutrition records, along with their refined temporal and geospatial resolutions, are essential for developing national and global priorities in food and nutrition.

Conclusion

We conducted a systematic review of nutrition dashboards and proposed detailed quality metrics that can serve as reference benchmarks to improve dashboards' performance and usability, avoid redundancy, and standardize the data-sharing process in nutrition population surveillance. Data standardization and harmonization will facilitate better communication among researchers, practitioners, and policy makers. Improved quality and usability of data dashboards will ensure that global nutrition problems can be identified and tackled in a more collaborative and precise manner using targeted and prioritized solutions.

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