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Survey of Brazilian Open Budget Data Portals: Query Interfaces and Dashboards

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Abstract To promote transparency, the Brazilian government provides access to public data through web portals featuring query interfaces and dashboards. While query interfaces are used by more experienced users to gather data for further analyses, dashboards that include visualizations help a broader audience consult and explore data. A domain of particular complexity that benefits from the use of these interfaces is government spending and budgets. This study analyzes dashboards and query interfaces of government budget data through qualitative research based on a survey. Focusing on Brazil's budget transparency initiative, we examined 83 interfaces in total: 30 dashboards and 53 query interfaces from federal, state, and major city governments. This survey assesses these interfaces using design patterns for general-purpose dashboards and design principles for open government data dashboards. Our findings reveal a critical weakness: while most portals provide access to budget data, they largely neglect user-centered design, failing to provide the necessary context or consider the data literacy of their audience. This creates a significant "transparency gap" that undermines genuine accountability and demonstrates the need for a fundamental shift in the design of these essential public tools.

Keywords: Data visualization, Open government data, Dashboards, Government Budget

1 Introduction

The availability of open data portals in Brazil has increased transparency and enabled access to information about public resource allocation [Matheus *et al*., 2012] [da União, 2024]. Many such portals provide access to data at all government levels (federal, state, and municipal). The main one is the *Dados Abertos*[1] (*Open Data*) portal, which serves as the central hub of the Brazilian government's open data infrastructure. This portal centralizes data from all areas of government activity and makes the datasets available for access and download through a query interface. Such publicly accessible data is valuable for researchers, journalists, and citizens. Individuals adept in analyzing such data contribute significantly to government accountability and public decision-making processes [Saliterer *et al*., 2018; Chokki *et al*., 2022].

Accountability refers to citizens holding the government accountable for its actions and decisions. Regarding the public budget, the government should be answerable to the people for how it handles public resources. Thus, transparency—i.e., the clarity, simplicity, and meaningfulness of the data presented to the public [Janssen and van den Hoven, 2015], and the means for citizens to access the data—contributes to effective accountability, promotes trust in the government, and helps prevent corruption as well as ensure that public power is exercised ethically and justly [Guerin *et al*., 2018].

In a democratic country, communicating information more intuitively is essential for transparency [Redden, 2018], and data visualization has become a common way to inform citizens. There are many ways to display data visually, and they can be available in different ways. One common platform that typically relies on visualizations is the *dashboard*. A dashboard is a graphical user interface model that consists of multiple interactive interface data elements (e.g., graphs, charts, and tables) on a screen. The primary purpose of dashboards is to present different but related data in a way that makes the information easier to understand.

One of the main advantages of dashboards is their versatility. They are highly customizable and can include a wide range of elements. This versatility makes them suitable for a great variety of contexts. Regarding government budgets, they can provide not only tables but also visual representations of the data, enabling citizens to understand the current state of the public budget: how resources are allocated, how they change over time, how they relate to revenue, etc. Dashboards are very important for government transparency initiatives, accountability, and public participation, as they help citizens understand and gain insight into the fiscal condition of the government level they are related to, the resource allocation choices, and how these choices support or hinder official policies [Saliterer *et al*., 2018].

Although practical and ever more common, dashboards are neither perfect nor suitable for every occasion. Much also depends on each dashboard's particular design. They can inform citizens as much as they can mislead them (whether intentionally or not) [Redden, 2018]. A common criticism of public sector dashboards concerns their ability to engage

[1] https://dados.gov.br/

citizens in daily inquiries [Chokki *et al*., 2022]. Moreover, numerous issues persist concerning their usability and assumptions by the dashboard designer about the user's knowledge of the domain [Kitchin and McArdle, 2017]. Examples of this are the Brazilian federal expenditure dashboard at the *Portal da Transparência*[2] and the Ministry of Planning, Budget and Management's *Orçamento em Números*[3] (*Budget in Numbers*). While these platforms are comprehensive in the data they present, they assume a familiarity with the country's financial structure that most ordinary citizens do not possess. As a result, extracting meaningful insights becomes difficult, limiting broader public engagement with these tools [Maheshwari and Janssen, 2014]. Interfaces following recommended design guidelines have increased the likelihood of citizens keeping track of the budget [Chokki *et al*., 2022], user engagement, and community participation in government decision-making in general [Matheus *et al*., 2020].

The main goal of this study is to survey budget-related dashboards and query interfaces provided by the Brazilian governments, analyzing them based on a set of design patterns outlined by Bach *et al*. [2023], and design principles proposed by Chokki *et al*. [2022]. To ensure completeness, our survey included not only dashboards but also query interfaces. Accordingly, we examined three federal open data portals, along with those available for states (47) and major cities (35). Our analysis considers two main user groups as the target audience for these platforms: 1) citizens with a basic understanding of politics and economics and a general interest in public finance, and 2) experts engaged in budget analysis who rely on these tools for more in-depth inquiry.

Our work assesses various essential aspects of public budget dashboards, encompassed by design principles. This is expressed in the following questions that we used for guiding our survey:

- Q1. Which resources do Brazil's federal, state, and municipal governments make available for citizens to access public budget data?
- Q2. How do these resources fare regarding the evaluation criteria, i.e., design principles?

This paper is organized as follows. Section 2 provides background on budget data and reviews related work. Section 3 outlines the methodology used in our survey. Section 4 presents the results, followed by a discussion of our findings in Section 5. Finally, Section 6 summarizes our answers to the research questions and outlines directions for future work.

2 Background and Related Work

This section provides an overview of various aspects related to government budget data portals. We will briefly address the following topics: budget data, dashboards and query interfaces for open government data, dashboard design guidelines (design patterns and principles), tasks related to budget data analysis, and user interfaces for Brazilian government budgets.

[2]https://portaldatransparencia.gov.br/despesas

[3]https://www.gov.br/planejamento/pt-br/assuntos/orcamento/orcamento/

2.1 Budget data

The public budget is a planning instrument that reflects the resources collected and spent by the government [Abreu and Câmara, 2015]. This topic should be of interest to citizens because it directly impacts people's daily lives through the many services governments provide—from healthcare and education to public safety and infrastructure. However, understanding budget data can be challenging due to complex terminology, overwhelming volume of information, lack of contextual explanations (i.e., the rationale behind allocation decisions), and the technical nature of the subject [Sicilia and Steccolini, 2017]. These challenges are further compounded by limited transparency and a shortage of accessible tools to help citizens navigate and interpret the data [Farazmand *et al*., 2022].

The public budget operates independently at each level of government (i.e., federal, state, and municipal). Still, its overall structure remains consistent, as budgetary law does not vary across these levels [Crepaldi and Crepaldi, 2017]. Expenditures are categorized as either *mandatory* or *discretionary*: mandatory expenses are legally required, while discretionary ones are determined through the budgeting process. Although there are several ways to classify budget data, the most commonly used scheme in Brazil is functional classification. This approach groups expenditures by government functions and sub-functions, organizing them according to the purposes they serve (e.g., healthcare, education, public safety, etc.).

Detoni *et al*. [2018] proposed a reference ontology for the Brazilian federal public budget, defining concepts, terms, and relations that allow answering 30 competency questions. These questions represent typical information needs for those seeking to understand the federal budget in detail–from the initial specifications of the Annual Budget Law (*Lei Orçamentária Anual, or LOA*) to the actual execution and payment of expenditures.

2.2 Visual interfaces for open government data

Dashboards are visual tools that support data exploration and interpretation. Analytical dashboards, in particular, feature more sophisticated interfaces with interactive functionalities such as selection, filtering, insertion, and the dynamic insertion or removal of information. These capabilities enable users to engage with the data in a more flexible and interactive manner, facilitating both the discovery of insights on their own and a clearer understanding of complex information curated for them. By contrast, query interfaces are simpler: they provide access to data but offer far less in terms of visualization and interactivity compared to dashboards.

Complementing both dashboards and query interfaces are visualizations—static or interactive visual representations of data that can function independently or be embedded within other interfaces. Visualizations enhance data understanding and communication by simplifying complex information, revealing patterns, supporting comparisons, and offering a more engaging user experience.

Many authors have examined the use of visual interfaces in improving the communication of government data.

A study by Matheus *et al*. [2020] examines interfaces de-

signed to improve transparency and accountability, focusing on their use by governments in decision-making processes. They analyzed two smart city cases that demonstrate the link between increasing transparency and accountability through the use of dashboards.

Young and Kitchin [2020] analyzed four city dashboards based on a user study with 21 participants, considering as analytical parameters their content, design, usability, and utility. The study was conducted following a concurrent think-aloud protocol, with the participants exploring the four dashboards in a counterbalanced order. The results of content and critical incident analyses performed on the outcomes of the user study guided the definition of guidelines for the Dublin city dashboard system. The guidelines focused on general principles related to navigation, data utility, style, visualizations, veracity, users, data types, usability, and communication.

Ansari *et al*. [2022] focuses on visualizations of open government data (OGD), surveying the academic literature on their development and evaluation. In their survey, they described the current state of the field, classified and synthesized the existing evidence on the development of OGD visualizations, and summarized the usability, successes, and challenges of these visualizations.

Notably, dashboards proved to be popular instruments for presenting public health data during the COVID-19 crisis. Inspired by the pandemic, Schulze *et al*. [2023] conducted a systematic literature review on the use of dashboards in the context of public health issues and diseases. Fareed *et al*. [2021] cataloged how information, system function, and user interfaces were designed across COVID-19 dashboards provided by the United States states. They also performed clustering analysis to group and characterize the dashboards based on the information collected and evaluated them in terms of how well they served the goals set forth by the Centers for Disease Control and Prevention, Essential Public Health Services.

2.3 User interface design patterns and guidelines

Drawing on a review of the literature and an analysis of real-world examples, Sarikaya *et al*. [2019] proposed design principles for dashboard development. They outlined a design space defined by key dimensions such as purpose, target audience, visual and interactive features, and data semantics. Based on this framework, they also identified four major types of dashboards: decision-making, awareness, motivation, and learning.

Building on this foundation, Bach *et al*. [2023] introduced a comprehensive set of design patterns for dashboards, informed by an analysis of 144 dashboards—83 from Sarikaya *et al*. [2019]'s corpus and 64 additional examples from news websites and applications across various domains (e.g., health, transport, energy, finance, etc.). They organized these patterns into eight groups, divided into two overarching categories: Content design patterns and Composition design patterns. While Content design patterns concern the types of data presented, their visual representation, and the inclusion of metadata, Composition design patterns address the structural and interactive aspects of dashboards, like page layout, screenspace used, structure, interaction, and colors. Further details on these design patterns are provided in Section 2.3.1.

Transitioning to a more specific perspective on dashboard design, Chokki *et al*. [2022] conducted a literature review of design guidelines for dashboards, analyzing city dashboards and extracting relevant user experience information. Their systematic review resulted in 16 design principles for government dashboards. As a concrete case, they developed *NBDash*, a budget dashboard for the Belgian city of Namur, based on these design guidelines. NBDash was built around two datasets, Namur-Ordinary Budget and Namur-Extraordinary Budget. It is accessible on the Namur open data portal [4]. Further details on these principles are provided in Section 2.3.2.

Expanding the focus to the broader public sector, Maheshwari and Janssen [2014] developed eight dashboard design principles and evaluated them through a detailed case study. These principles address key aspects such as customizing and selecting metrics using existing data sources, linking performance indicators to the overall processes and procedures, analyzing the impact of improvement options, and using visual communication to support monitoring, analysis, and performance assessment. Additional principles include integrating multiple small dashboards into a single, unified one and fostering data interpretation, learning, and growth. They applied these principles to categorize various types of public sector dashboards based on their design features and intended functions.

In our work, we adopted the dashboard design patterns proposed by Bach *et al*. [2023] and the design principles from Chokki *et al*. [2022] to analyze the Brazilian budget data portals. These frameworks provided a robust foundation for evaluating the structure, content, and usability of the portals, and they inform the analytical approach detailed in the following sections.

2.3.1 Design patterns

Bach *et al*. [2023] identified recurring *design patterns* in dashboards that have typical applications for public data visualization. These patterns reflect layout, interaction, and visualization strategies employed across multiple platforms. We used them as an analytical layer to identify structural or navigational flaws in the interfaces surveyed.

As mentioned before, the analysis of the dashboards' design patterns revealed eight design patterns divided into two broad categories: Content design patterns and Composition design patterns. Content design patterns were grouped into three subcategories – Data Information, Metadata, and Visual Representation. Composition design patterns were organized into five subgroups – Page Layout, Screenspace, Structure, Interaction, and Color.

Moreover, the shared characteristics, design pattern combinations, usage contexts, or communication goals led the authors to define six dashboard genres as follows:

- Static
- Analytic
- Magazine

[4] https://data.namur.be/pages/accueil/

- Infographic
- Repository
- Embedded mini-dashboards

They further grouped these genres into two broader types: Curated dashboards, which are more author-driven and emphasize selective storytelling through data and visuals; and Data collections, which are more reader-driven and designed to present large volumes of information in a way that helps users find what matters most to them.

Curated dashboards encompass Static, Magazine, and Infographic dashboards that are tailored for a specific goal. They usually fit on a single screen. Data collections, in turn, provide access to large volumes of data in the form of Analytic or Repository dashboards. They usually spread over a number of pages.

Bach *et al*. [2023]'s extensive set of guidelines for dashboard design is available at their Dashboard Design Patterns website [5].

2.3.2 Design principles

Chokki *et al*. [2022] proposed a set of design principles for dashboards focused on open government data. These principles aim to enhance usability and user engagement by addressing common challenges in visualizing complex public data. Broadly, the principles include:

- Task Orientation: Dashboards should support specific analytical tasks, such as comparisons, filtering, trend analysis, and drill-downs.
- Contextualization: Data should be presented in a context that helps users interpret it correctly, avoiding misrepresentation.
- Transparency: The dashboard should explain the metrics calculus working, include data provenance, and indicate update frequency.
- Clarity and Simplicity: Visual elements must be intuitive, with minimal cognitive load for users unfamiliar with the domain.
- Feedback and Interaction: Users should receive clear feedback for their actions (e.g., filtering, clicking), enabling meaningful exploration.

The 16 principles by Chokki *et al*. [2022] are as follows:

- P1: Pick meaningful metrics
- P2: Collect accurate and precise data
- P3: P3: Ensure your data makes sense
- P4: Consider the audience
- P5: Use the best visualization practices
- P6: Use the correct type of chart
- P7: Provide easy-to-use tools
- P8: Clear presentation
- P9: Provide context and data interpretation support
- P10: Think about data literacy levels
- P11: Ensure data is up to date
- P12: Allow access to data source
- P13: Check for personal data/outliers
- P14: Interaction support
- P15: Ensure feedback support
- P16: Customization

The design patterns and principles are particularly relevant for budget transparency portals, where data complexity, scale, and public significance demand careful visual communication. Dashboards that adhere to these guidelines are more likely to support analytical tasks such as exploring spending categories, tracking budget execution, or comparing allocations over time and regions. This way, they are also likely to meaningfully promote citizen engagement due to the level of transparency they can support. Conversely, dashboards that neglect these principles may reduce the effectiveness of transparency efforts.

2.4 Analytical tasks related to budget data

Open budget portals aim to support analytical tasks, which help users explore, understand, and assess public budget data. We identified such analytical support surveying the literature on budget data dashboards and applications [Chokki *et al*., 2022; Silva *et al*., 2019] and the competence questions listed by Detoni *et al*. [2018] in their reference ontology.

Users should be able to analyze retrieved data, such as expenses and revenues, through charts and tables, and compare them. Also, it is common for portals to make available historical data from recent years so users can observe patterns and trends over time. In this context, the audience is citizens with basic knowledge of public administration.

While developing the reference ontology for the Brazilian public budget, Detoni *et al*. [2018] listed 30 competence questions (CQ), which can be translated into analytical tasks, that are included in the general tasks above. The CQs are divided into groups depending on the budget phase they are related to. The predicted tasks, therefore, involve obtaining information about the following aspects:

- Budget law and the derived authorizations (4 CQs)
- Previously authorized expenses (10 CQs)
- Actual payments (7 CQs)
- Final phase of expenses payment (8 CQs)

As such, in general, obtaining information about budget data involves the following tasks:

- Exploratory analysis: Users navigate and explore to understand spending and revenue allocation by the government.
- Comparative analysis: Users identify patterns over time and compare budgetary allocations.
- Custom queries and downloads: Users generate custom queries or download data for offline, specific analysis.

2.5 User interfaces for Brazilian government budget data

In Brazil, all levels of the federation—federal, state, and municipal—are required to provide access to data under the

[5] https://dashboarddesignpatterns.github.io

Information Access Law[6].

The *Portal da Transparência* (*Transparency Portal*)[7] offers general and specific charts depicting budgetary expenses and the overall budget. Among the available functionalities, it is possible to view different charts, export these charts, query the database, and export the retrieved data.

More detailed data about the Brazilian budget is available at the Senate's SIGA Brasil portal[8], which provides simple QlikView dashboards intended for non-expert citizens as well as a more advanced interface based on the SAP BusinessObjects WebIntelligence platform, which enables users to create interactive reports and analyze data using spreadsheets and charts but requires deeper knowledge of the budget.

Simple QlikView dashboards for the general public are also provided at the *Sistema Integrado de Orçamento e Planejamento* (Integrated Planning and Budget System) - SIOP's website[9]. These include the Budget Panel and the Digital Citizen Budget. SIOP also makes available an open data webpage with documents and budget datasets as well as a SPARQL endpoint that gives access to budget data since 2001.

Government data portals have traditionally been evaluated using the Brazil Transparency Scale (*Escala Brasil Transparente*, or EBT). As an alternative, Noceti [2019] proposed the Santa Catarina Transparency Scale, designed to assess active transparency—i.e., the proactive publication of information—rather than the passive transparency emphasized by the EBT, which focuses on responding to user requests. Their goal was to create a more practical tool, especially for small municipalities, to self-assess their portals. They applied the scale on 12 municipal portals in the state of Santa Catarina.

The current EBT methodology—known as the "360º Evaluation" [10]—now incorporates both passive and active transparency. It evaluates factors such as the publication of information on revenues and expenditures, procurement and contracts, administrative structure, public employees, and the monitoring of public works, among other areas. However, it does not assess how information is presented. As a result, portals often provide access only to raw data in textual format, either directly on web pages or as downloadable files.

During the collection phase of our survey, we observed that such interfaces are an overlooked subject in the human-computer interaction and visualization communities. We did not find any specific references related to providing access to budget data in Brazil, except for the work by Silva *et al*. [2019]. These authors aimed to improve the search and access to information related to agreements and transfer contracts of the Federal government. Such data is available from a portal named SICONV[11]. However, the portal provides web pages with menus and forms that the user has to fill in to consult, which makes it difficult for laypeople to access the data. Silva *et al*. [2019] developed FiscalizaBR, a web and mobile application that allows users to access the same data. They compared *FiscalizaBR* to SICONV, in an experiment involving six scenarios and typical user tasks performed using both platforms. *FiscalizaBR* was shown to be more effective and efficient than SICONV.

Given this context, to the best of our knowledge, our work is the first one to survey the set of user interfaces provided by the federal government, states, and capital cities in Brazil, looking specifically for means to access the budget data.

3 Methodology

This study followed a five-step qualitative methodology to survey and analyze Brazilian budget portals (Fig. 1). The process was designed to systematically collect, analyze, and classify interfaces based on Bach *et al*. [2023]'s dashboard design patterns and Chokki *et al*. [2022]'s dashboard design principles. To ensure consistency, one author conducted the analysis and classification of the website interfaces, while the remaining authors reviewed the tables to discuss and validate the results.

Step 1: Data collection

To build our corpus, we conducted a comprehensive search across all levels of government—federal, state, and municipal—using keywords such as "portal da transparência" ("transparency portal") and "dados abertos" ("open data") combined with city or state names. Transparency portals served as our primary sources, supplemented by other government websites related to budget, planning, and economic policy. At the municipal level, we limited our scope to state capitals. This approach yielded a diverse corpus of 30 dashboards and 53 query interfaces (Table 1, Section 4).

Step 2: Feature extraction

For each interface in our corpus, we systematically identified and recorded its components and characteristics. This process involved examining each portal to catalog its visual and interactive elements, such as the types of charts used (e.g., bar, pie, line), the availability of filters and search bars, data download options, and the presence of explanatory text or tooltips. For example, in analyzing the federal portal *Portal da Transparência*, we noted the inclusion of a variety of chart types, interactive filters for drilling down into data, and the ability to export datasets as CSV files. In contrast, for a simpler query interface like that of the city of Macapá, we recorded the primary feature as a table-based data presentation with basic filters. This detailed feature inventory served as the empirical basis for the subsequent analysis steps.

Step 3: Design pattern analysis

Using the extracted features, we analyzed each interface against the design patterns proposed by Bach *et al*. [2023]. This involved mapping the observed features to their corresponding patterns. For example, an interface presenting a primary grid of rows and columns was identified as using the *Table* representation pattern, which is one of the groups of the Content design patterns. If its content required scrolling to view completely, it was also classified under the *Overflow*

[6] Lei de Acesso à Informação (LAI) No. 12,527, enacted on November 18, 2011

[7] https://portaldatransparencia.gov.br/despesas

[8] https://www12.senado.leg.br/orcamento/sigabrasil

[9] https://www.siop.planejamento.gov.br/modulo/login/index.html

[10] https://mbt.cgu.gov.br/publico/portal/metodologia360edicao2/66

[11] https://transferegov.com.br/

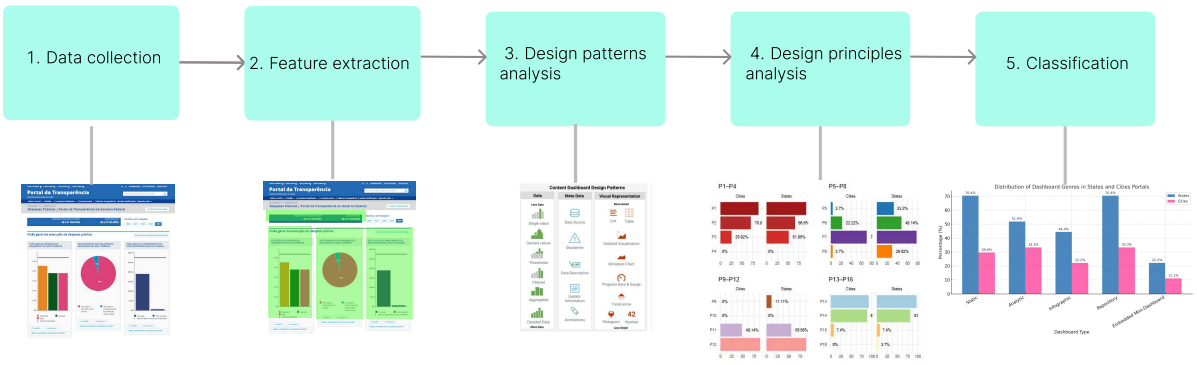


Figure 1. Workflow of our study.

screenspace pattern, which is one of the five Composition design patterns. An interface that allowed users to refine the displayed data using drop-down menus was identified as supporting the *Filter and Focus* interaction pattern that is also a Composition design pattern. This systematic mapping allowed us to deconstruct each interface into a collection of established design solutions, which are reported in Tables 2 and 3.

Step 4: Design principle analysis

We then evaluated each interface for its adherence to the 16 design principles for open government data dashboards proposed by Chokki *et al*. [2022]. This was a qualitative assessment based on the features extracted in Step 2. For each principle, we established criteria for compliance. For instance, to assess adherence to principle **P1 (Pick meaningful metrics)**, we checked if the portal presented standard, understandable budgetary terms like "Revenues" and "Expenses" rather than obscure technical codes. To assess principle **P12 (Allow access to data source)**, we verified the presence of a functioning download link for the raw data. For principle **P11 (Ensure data is up to date)**, we looked for an explicit "last updated" date on the portal. Each interface was marked as compliant or non-compliant for each of the 16 principles, with the results compiled in Tables 4 and 5.

Step 5: Classification

In the final step, we synthesized the findings from the design pattern analysis to classify each dashboard according to the six dashboard genres defined by Bach *et al*. [2023]: Static, Analytic, Magazine, Infographic, Repository, and Embedded mini-dashboards. This classification was based on the combination of design patterns identified in Step 3. For example, a dashboard characterized by high interactivity, multiple filtering options, and detailed visualizations was classified as an *Analytic* dashboard. A portal that primarily functioned as a gateway to downloadable datasets with minimal visualization was classified as a *Repository*. The resulting genre for each dashboard is presented alongside the design principle analysis in Tables 4 and 5.

4 Results

Our survey of Brazilian budget data portals yielded a diverse corpus of 30 dashboards and 53 query interfaces (Table 1 and Figure 2), spanning a range of government levels and regions. This section presents the findings of our analysis, focusing first on the prevalence of different design patterns and then on the adherence to established design principles. Please note that federal interfaces are always included among state interfaces.

Table 1. Number of collected dashboards and query interfaces.

	Federal	State	City	N
Dashboards	2	19	9	30
Query interfaces	1	26	26	53

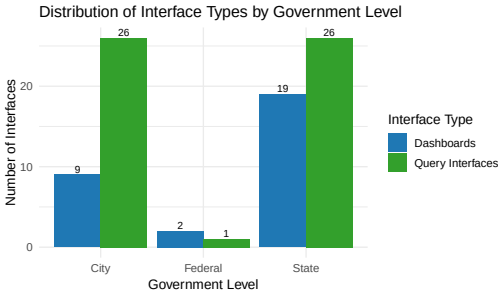


Figure 2. Distribution of interface types by government levels.

4.1 Dashboard Design Patterns

Our analysis, summarized in Tables 2 and 3 for capital cities and states, respectively, identified recurring design patterns across the surveyed interfaces. The findings are broken down by Content and Composition design patterns. We also present the classification of dashboards following Bach *et al*. [2023]'s genres.

4.1.1 Content Design Patterns

Content patterns relate to the data itself and its visual representation. The analysis revealed a strong reliance on basic visual presentation methods. The distribution of Content design patterns across states' capital cities, and states and the

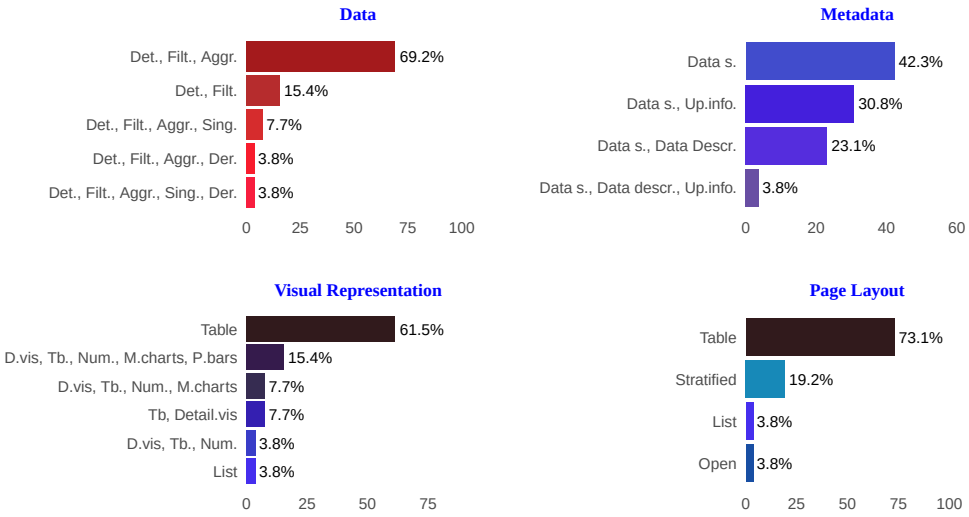


Figure 3. Distribution (%) of Content design patterns across city interfaces.

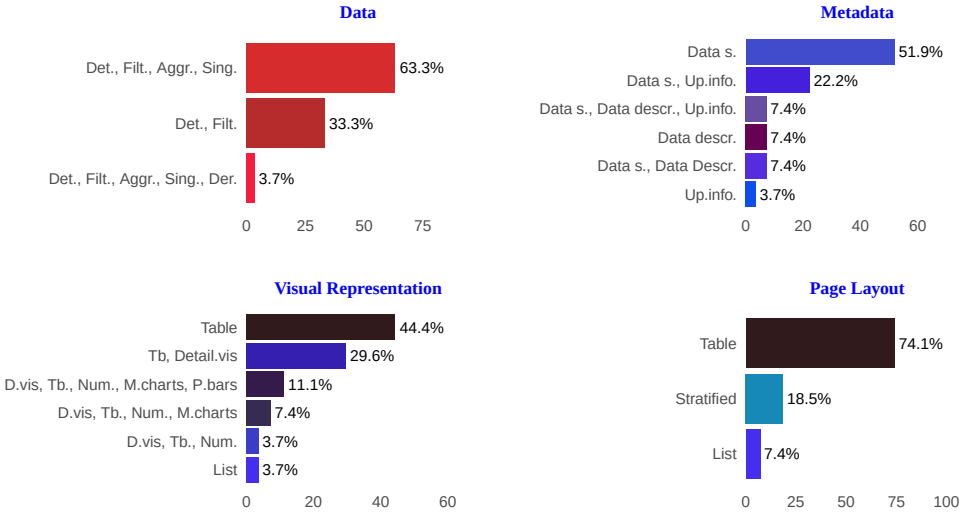


Figure 4. Distribution (%) of Content design patterns across federal and state interfaces.

federal budget dashboards is presented in Figures 3 and 4, respectively.

Data: All surveyed interfaces provide access to a *Detailed* dataset, and all allow for some form of *Filtering*. *Aggregated* patterns for data summaries are also common, present in 66.7% of state and 84.6% of city interfaces. *Single value* patterns are used to show specific data in a dataset and are present in 66.7% and 7.7% of state and city interfaces, respectively. However, more advanced data representations are rare; *Derived values* (e.g., per capita spending) appear in only 3.7% of state and 7.6% of city interfaces.

Metadata: The most common metadata element is the provision of a *Data source* link, found in 96.3% of state and 100% of city portals. Information about when the data was last updated (*Update information*) is less frequent, appearing in about a third of interfaces at both state (33.3%) and city (34.6%) levels. Explanatory *Data descriptions* are even rarer (22.2% of state, 26.9% of city interfaces). The other patterns in this category were not found.

Visual representation: The *Table* is the dominant form of visual representation, used in 96.3% of state and 92.4% of city interfaces. More complex *Detailed visualizations* (e.g., interactive charts) are present in less than half of the portals (48.8% of state, 35.6% of city). Other visual forms are used sparingly: *Miniature Chart* (18.5% of state and 23.1% of city interfaces); *Progress Bars* (11.1% of state and 15.4% of city interfaces); *Numbers* appear in 22.2% of state and 23.1% of city interfaces, and *List* is used in 3.7% of state and 3.8% of city interfaces.

4.1.2 Composition Design Patterns

Composition design patterns relate to the layout, screenspace, structure, interaction, and color scheme features of the interface. The distribution of Composition design patterns across states' capital cities, and states and federal dashboards is presented in Figures 5 and 6, respectively.

Page layout: The most common layout is the *Table* pattern,

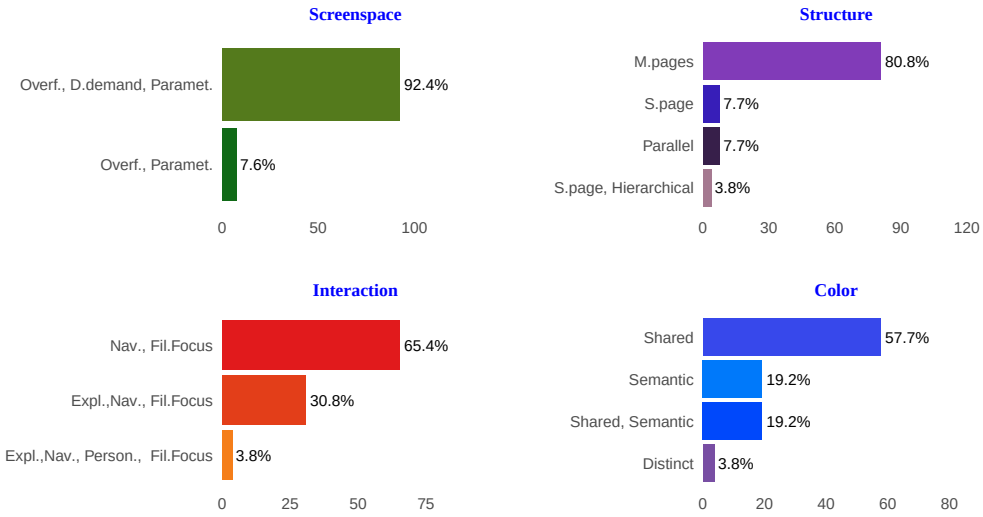


Figure 5. Distribution (%) of Composition design patterns across city interfaces.

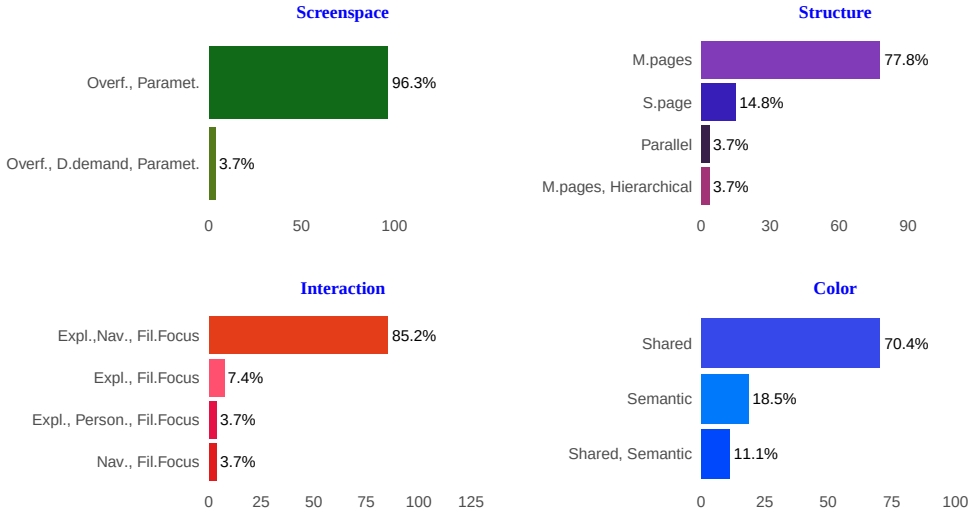


Figure 6. Distribution (%) of Composition design patterns across federal and state interfaces.

dominating both state (74.1%) and city (73.1%) interfaces. More sophisticated layouts like *Stratified* (grouping related elements) are less common (18.5% state, 19.2% city interfaces). The *List* pattern appears in 7.4% of state and 3.8% of city interfaces. Similarly, the *Open* pattern is used in only 3.8% of interfaces.

Screenspace: Nearly all interfaces use *Overflow* (requiring scrolling) and *Parameterization* (using filters to change the view). The vast majority are structured across *Multiple Pages* (81.5% state, 80.8% city interfaces), in contrast with the *Detail-on-Demand* pattern that is used in merely 3.7% (state) and 7.6% (city) interfaces.

Structure: In this category, the *Single Page* pattern appears in 14.8% and 11.5%, in state and city interfaces, respectively, while the other patterns (*Parallel* and *Hierarchical*) are seldom used (3.8%) in both state and city interfaces.

Interaction: All interfaces provide basic *Navigation* and *Filter and focus* capabilities. However, the *Exploration* patterns (e.g., drill-downs, linked views) are more common in state interfaces (96.3%) than in city interfaces (34.6%). *Personalization* is almost non-existent (found in only one state and one city portal, totaling around 3.8% of the interfaces).

Color: Most interfaces use a *Shared* color scheme for consistency (81.5% state, 76.9% city). The use of *Semantic* pattern (where colors have specific meanings, e.g., red for deficit) is less frequent (29.6% state, 23% city).

4.1.3 Dashboards Classification

Based on the combination of design patterns, we classified the 30 dashboards in our corpus into Bach *et al*. [2023]'s genres. Their distribution can be seen in Figure 7.

The most common genres were *Repository* (70.37% of state, 33.3% of city dashboards) and *Static* (70.37% state, 29.62% city), reflecting a tendency towards simple, non-interactive data presentation.

Analytic dashboards, which are data-driven and support deeper exploration, were present in about half of the state dash-

boards (51.85%) but only a third of city dashboards (33.3%). On the other hand, *Infographic* dashboards combine static and interactive elements, with a greater focus on visual engagement than detailed exploration, and were found in 44.4% of states and 22.22% of cities' portals.

The least used genre is *Embedded mini-dashboard* (22.22% of state, 11.1% city). They are designed to provide quick insights or summaries, often with limited interactivity, and are highly contextual to a host application. Finally, no dashboards fit the narrative-driven *Magazine* genre.

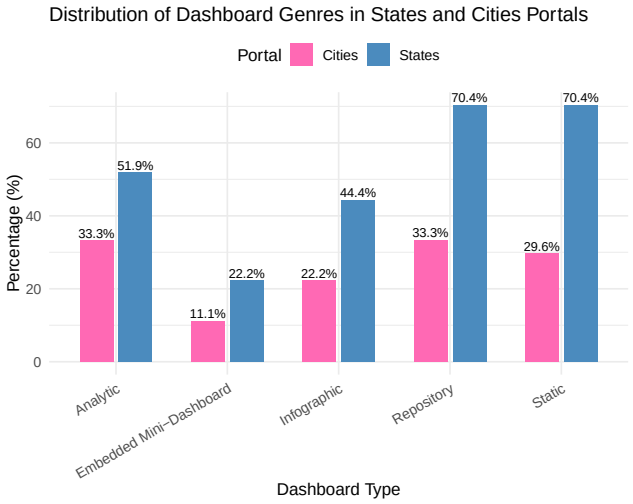


Figure 7. Distribution of dashboards across Bach *et al*. [2023]'s genres.

4.2 Interface Design Principles

The adherence of the surveyed interfaces to the 16 design principles proposed by Chokki *et al*. [2022] is detailed in Tables 4 and 5 (for states' capital cities and states, respectively), with overviews provided in Figures 8, 9, and 10.

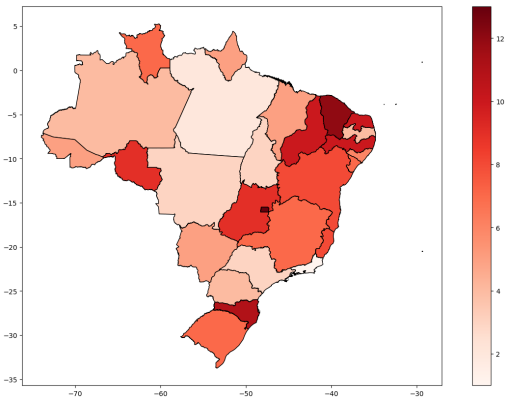


Figure 8. States applying design principles in their budget open data portals: color indicates the amount of principles followed by the state dashboard.

In the following, we provide more details and quantitative results for each design principle.

P1: Pick meaningful metrics: Using meaningful and understandable parameters is essential for citizens to comprehend the information related to the government budget and increase their engagement. To validate this principle, exploratory and comparative analysis tasks allow users to

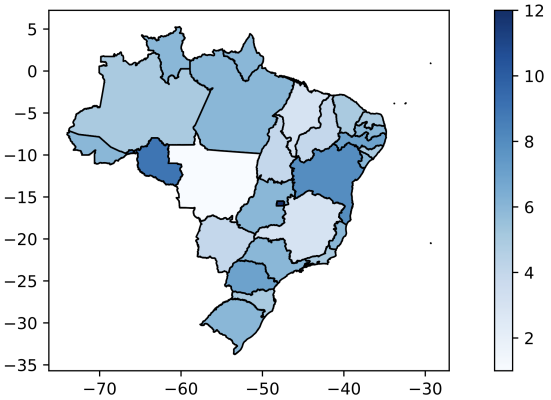


Figure 9. Cities applying design principles in their budget open data portals: color indicates the number of principles followed by the city dashboard.

observe the public budget data, such as expenditures and revenues. Our analysis showed that 88.8% of state and 92.59% of city interfaces follow this principle.

P2: Collect accurate and precise data: The budget interfaces should present reliable data to allow citizens to understand and trust the public budget. Portals that present interactive elements to enable the exploratory and comparative analysis, applying filters to locate the information, follow this principle. We found that 70.83% of city and 66.6% of state interfaces show accurate data.

P3: Ensure your data makes sense: Data should be consistent, i.e., summarizing or aggregating data does not introduce inconsistencies. By inspecting the visual interfaces and the downloaded data, we found many interfaces presenting differences between the information on the website and the downloaded data. Only 25.92% of city interfaces present consistent data, while for states this number is higher (51.85%).

P4: Consider the audience: The budget open portals need to communicate the information at the level of detail the citizens need and, more importantly, can understand. Not all websites explain budget concepts that focus on the general public. Moreover, all query interfaces allow data to be downloaded but require previous user knowledge. Thus, none of the interfaces considers different user profiles.

P5: Use the best visualization practices: The best visualization practices are those that are based on minimal yet interesting charts that help users understand the data. For instance, bar charts and stacked bar charts facilitate data comprehension. We found that only 3.7% of city and 33.3% of state interfaces provide simple visualizations. The remaining interfaces predominantly rely on more complex visualizations, such as treemaps, Sankey diagrams, radar charts, bubble charts, and interactive network graphs, which, although visually engaging, often require higher levels of data literacy and may hinder straightforward interpretation by the general public.

P6: Use the correct type of chart: Data can be more easily understood depending on the right choice of graphs regarding the type of data and the target audience. As for the budget data domain, bar charts, stacked bar charts, pie charts, and line plots are considered adequate choices due to their simplicity and compatibility with numerical and categorical data. Only 22.22% of city and 48.14% of state portals follow this principle.

P7: Provide easy-to-use tools: Although we have not

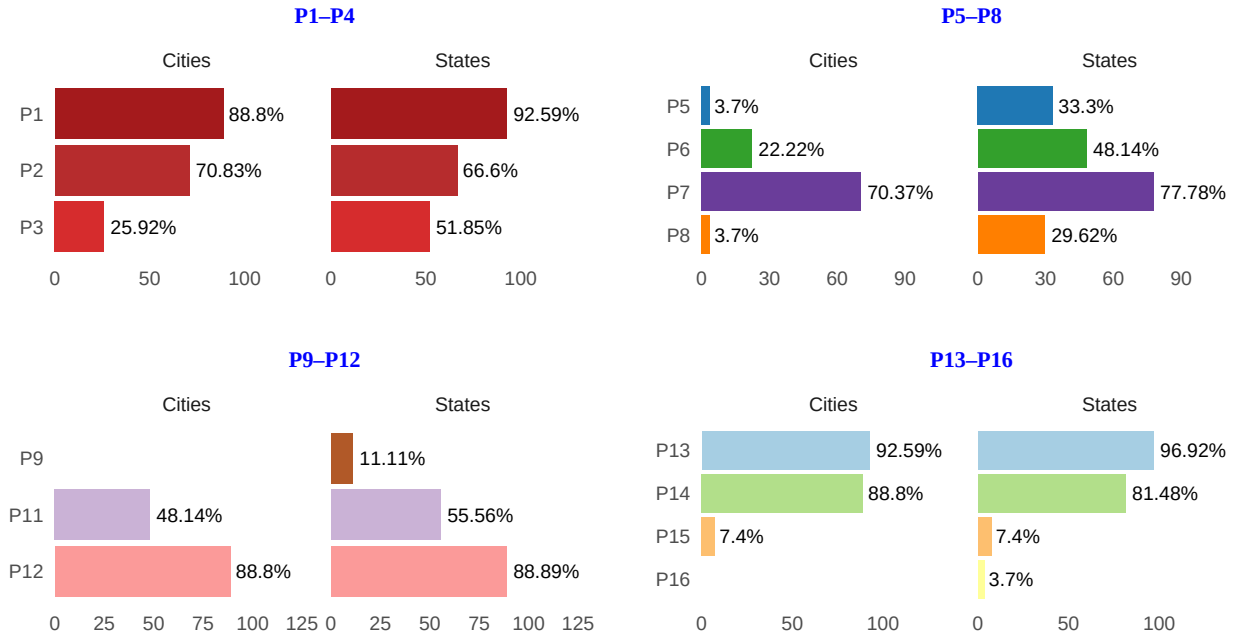


Figure 10. Distribution of Chokki *et al.* [2022]'s principles across capital city, state, and federal interfaces. P4 and P10 are not shown because no interface is compliant with them.

performed an extensive usability test involving different kinds of users, our inspection of the interfaces showed that most of them (70.37% of city and 77.78% of state interfaces) provide simple interactive features. We based our analysis on Kitchin and McArdle [2017], which affirm that budget dashboards that provide simple tools for the user to access and interact with the visualizations follow this principle.

P8: Clear presentation: Clear presentation involves the ability of a dashboard to effectively communicate essential information about a dataset through coherent and accessible design choices. To assess this principle, we examined multiple aspects highlighted in visualization literature, including layout organization, responsiveness to screen size, consistency of color scheme, typography, labeling, use of whitespace, and avoidance of visual clutter. Our inspection revealed that only one city interface (Porto Velho) and 29.62% of state interfaces could be considered to follow this principle. While our evaluation provides useful insights, we acknowledge that a comprehensive assessment of clarity would require empirical usability testing with end users, which we identify as an opportunity for future work.

P9: Provide context and data interpretation support: Considering that not all citizens can comprehend budget data based only on the visualization, the interfaces should add contextual information that helps interpretation. Only 11.11% of state interfaces provide context to the charts through another form of communication. In contrast, none of the city interfaces follow this principle.

P10: Think about data literacy levels: Like principle P4, we found that all 30 dashboards and 53 query interfaces lack features compliant with different user literacy levels.

P11: Ensure data is up to date: To keep citizens informed about the allocation of resources, ideally, data should be constantly updated. At least, the update date should be informed. We found that 48.14% of city and 55.56% of state interfaces meet this criterion.

P12: Allow access to data source: The budget dashboards should allow extracting data from the available data sets. Around 88% of city and state interfaces provide such a feature.

P13: Check for personal data/outliers: This principle means that one needs to ensure the confidentiality of the data because much of the government data is collected from citizens. We found that none of the portals show data that would violate this principle.

P14: Interaction support: Most budget dashboards and query interfaces (88.8% of city and 81.48% of state interfaces) provide some level of interaction.

P15: Ensure feedback support: Feedback is important for all kinds of user interfaces to improve user experience based on user feedback. Regarding budget data portals, another use of feedback would be reporting corruption or fraud suspicion. We found that only 7.4% of state and city interfaces collect feedback from users.

P16: Customization: This principle is related to features that would allow users to customize existing dashboards and also get enough information (for example, the source code) to create their own dashboards. None of the existing city and state budget data dashboards is compliant with this principle.

The analysis we described above was focused on state and city budget data portals only. The federal portal *Portal da Transparência* was the most compliant interface in the survey, adhering to 14 of the 16 principles, failing only on P4 and P10 (Figure 11).

Our study revealed a clear bifurcation. High compliance was observed for principles related to core data provision. For example, P13 (Check for personal data/outliers) was met by all interfaces. High compliance was also recorded for P1

(Pick meaningful metrics) with more than 90% of states and cities, and P12 (Allow access to data source), with more than 88% across both state and city levels.

Conversely, principles related to user experience and contextualization showed extremely low compliance. Notably, P4 (Consider the audience) and P10 (Think about data literacy levels) were not met by any of the 83 surveyed interfaces. Similarly, P9 (Provide context and data interpretation support), P15 (Ensure feedback support), and P16 (Customization) were almost entirely absent from the portals.

5 Discussion

Our survey of Brazilian budget portals reveals a significant gap between the goals of open government and the reality of the tools provided to citizens. While the infrastructure for transparency exists, its effectiveness is consistently undermined by a lack of user-centered design. Interpreting our results through the lens of established design principles highlights several critical challenges that prevent meaningful public engagement with budget data.

A key strength of the current landscape is that most portals successfully fulfill the basic tenets of data release. The high adherence to principles like providing access to the data source (P12) and using meaningful metrics (P1) shows a clear intent to be transparent. However, this foundational strength is immediately undercut by the most critical weakness: a complete failure to consider the user. The fact that not a single portal addressed the varying data literacy of its audience (P4, P10) is a profound shortcoming. It suggests that these portals are built primarily as data repositories for experts, not as educational tools for the general public.

This expert-centric approach is most evident in the large predominance of query-based interfaces. While these portals technically fulfill the mandate to release data (due to the transparency law), they present a major barrier to the average citizen. Interfaces like Macapá's (Figure 12)—essentially filterable tables—demand pre-existing knowledge of budgetary terms and data analysis. This creates a "transparency gap": the data is public, but it is not truly accessible or comprehensible to a non-expert audience. This limits genuine accountability to a small group of specialists.

Where dashboards do exist, they often fail to deliver on their potential. Many are plagued by generic charts and poor adherence to visualization best practices (violating principles P5 and P6), as seen in the Maceió dashboard (Figure 13). Even the federal portal *Portal da Transparência*—while technically robust—falls short of its potential by assuming a level of financial literacy that most citizens do not possess. They are powerful tools for experts, but they are not effective instruments for broad public education and oversight.

Beyond high-level design choices, practical issues frequently hinder access. During our survey, several portals (e.g., Rio de Janeiro, Vitória) were intermittently unavailable. Others, like Rio Branco's, suffered from poor navigation, while the city of Campo Grande provides no interface at all, offering only static PDF documents. These fundamental issues suggest that for some government bodies, the transparency portal is a low-priority item, maintained only to meet minimum legal requirements.

In contrast, the portal for the Distrito Federal (Figures 14 and 15) stands as a notable exception, successfully implementing 14 of the 16 design principles. Its clear presentation and interactive features demonstrate that creating a usable and informative budget portal is achievable, and it serves as a strong model for other governments to follow.

Ultimately, this survey demonstrates that simply making data available is not enough. For Brazil's open budget initiatives to foster genuine transparency and accountability, a fundamental shift is required: from a focus on data publication to a focus on user-centered communication and design.

6 Conclusion

This paper presented a systematic survey of the budget dashboards and query interfaces provided by Brazil's federal, state, and capital city governments. By analyzing these 83 portals against established design patterns and principles, we sought to answer two key questions regarding the state of public budget data resources in the country.

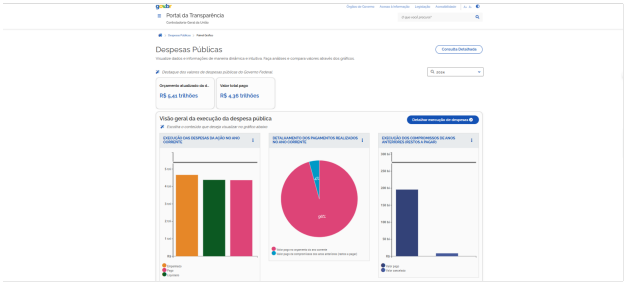
In response to our first question (Q1), we found that while nearly all government entities provide some form of access to budget data, the quality and utility of these resources vary dramatically. Our findings for the second question (Q2) reveal that the vast majority of portals fail to adhere to user-centric design principles. While some, like the portals for the Federal District and the state of Ceará, are notable exceptions, the broader landscape is characterized by a lack of features that would empower ordinary citizens. This focus on raw data publication over user comprehension may discourage public engagement and hinder true financial accountability.

The primary contribution of this work is providing the first comprehensive assessment of Brazilian budget portals through the dual lens of Bach *et al*. [2023]'s design patterns and Chokki *et al*. [2022]'s design principles. This creates a valuable baseline for researchers and policymakers. Based on our findings, we propose two avenues for future research. First, a constructive path focused on designing and evaluating new budget dashboards that explicitly incorporate the principles found to be lacking in this survey. Second, an expansive path to apply this evaluative methodology to other critical areas of government transparency, such as public health or education portals.

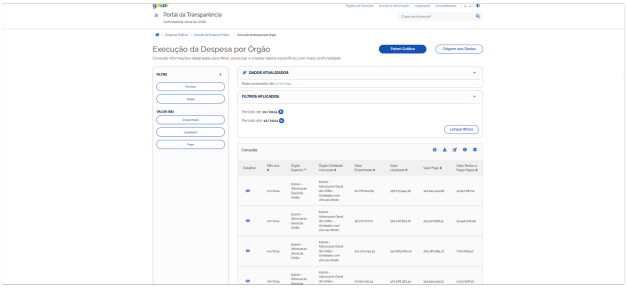
Ultimately, this study demonstrates that for open government initiatives to succeed, a fundamental shift is required—from merely making data available to communicating it effectively. Moving from a culture of data compliance to one of user-centered design is essential for fostering a more informed and engaged citizenry in Brazil.

(A) Initial page of Transparency portal. This page applies the principles P5 (Best visualizations practices), P7 (Easy tools), P8 (Clear presentation), P9 (Context and data interpretation support), P11 (Update data), P12 (data source access), P14 (Interaction support), and P15 (Feedback support).

(B) Public expenditure page of Transparency portal. This page applies the principles P5 (Best visualizations practices), P7 (Easy tools), P8 (Clear presentation), P9 (Context and data interpretation support), P11 (Update data), P12 (data source access), P14 (Interaction support), and P16 (Customization).



(C) Public expenditure dashboard of Transparency portal. This page applies the principles P1 (Meaningful metrics), P2 (Precise data), P3 (Data makes sense), P5 (Best visualizations practices), P6 (Correct chart), P7 (Easy tools), P8 (Clear presentation), P9 (Context and data interpretation support), P11 (Update data), P12 (data source access), P14 (Interaction support), and P16 (Customization).



(D) Public expenditure page of Transparency portal. This page applies the principles P5 (Best visualizations practices), P7 (Easy tools), P8 (Clear presentation), P9 (Context and data interpretation support), P11 (Update data),P12 (data source access), P14 (Interaction support), and P16 (Customization).

Figure 11. Parts of the *Portal da Transparência* indicating which principles they are compliant to.

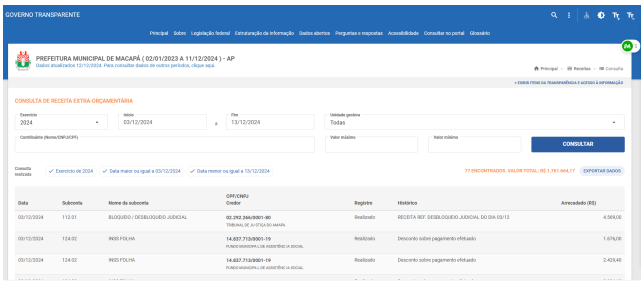


Figure 12. Macapá city's budget query interface

Figure 14. Distrito Federal's budget website

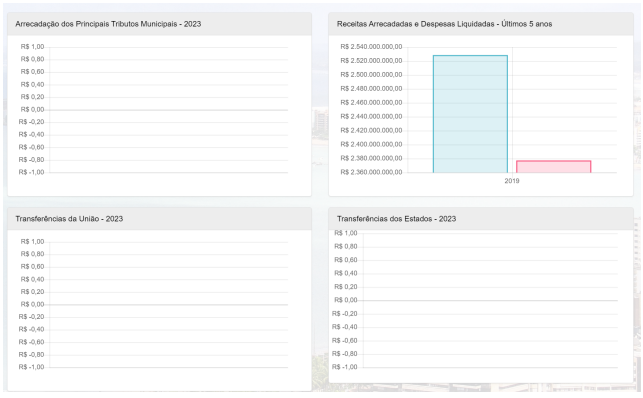


Figure 13. Charts in the Maceió city's budget dashboard

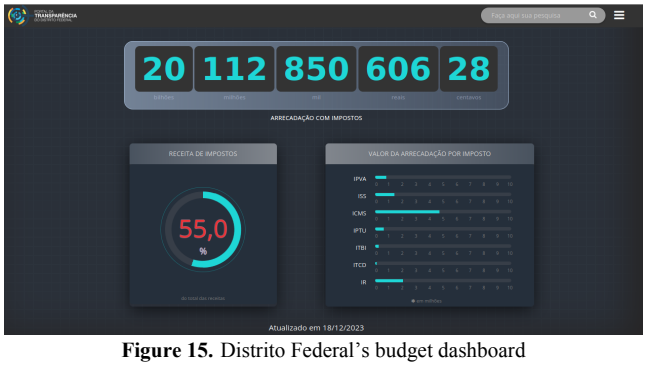


Figure 15. Distrito Federal's budget dashboard

Declarations

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Authors' Contributions

All authors contributed to the conception of the study. K. B. F. Mesquita was responsible for data collection, feature extraction, and analysis. C.M.D.S. Freitas validated the collected data and extracted features. All authors discussed the results. K. B. F. Mesquita wrote the first draft of this manuscript. D. G. Balreira, A. S. Spritzer, and C.M.D.S. Freitas reviewed the manuscript, making several contributions to the writing of the original submission. Finally, C. M. D. S. Freitas and A. Spritzer contributed extensively to the writing of the revised version of the article.

Competing interests

All the authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and materials

Supplementary material is available as an .xlsx file.

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Table 2. Content and composition dashboard design patterns of the budget open portals of major cities in Brazil. Also shown if the portal features a dashboard and a query interface, and dashboard genre: (1) Static, (2) Analytic, (3) Infographic, (4) Repository, and (5) Embedded mini-dashboards.

Nº	***Cities***	**Content dashboard design patterns**			**Composition dashboard design patterns**					**Dashboard**	**Query interf.**
		Data	**Meta Data**	**Visual repr.**	**Page layout**	**Screenspace**	**Structure**	**Interaction**	**Color**		
1	*Rio Branco*	Filtered	Data source	Detailed vis	Aggruped	Parametrization	Single page	Exploration	Emotive	1,2,4,5	✓
2	*Maceió*	Filtered	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
3	*Macapá*	Detailed	Data source	Miniature chart	Table	Overflow	Parallel	Exploration	Distinct		✓
4	*Manaus*	Filtered	Data source	Table	Table	Overflow	Parallel	Navegation	Shared		✓
5	*Salvador*	Detailed	Data source	Detailed vis	Stratified	Overflow	Single page	Exploration	Semantic	1,2,3,4	✓
6	*Fortaleza*	Detailed	Data source	Table	Table	Overflow	Single page	Navegation	Shared		✓
7	*Brasília*										
8	*Vitória*	Detailed	Data descrip	Detailed vis	Stratified	Overflow	Multiple pages	Exploration	Semantic	1,2,3,4,5	✓
9	*Goiânia*	Detailed	Data descrip	Detailed vis	Stratified	Overflow	Multiple pages	Exploration	Semantic		✓
10	*São Luís*	Detailed	Data source	Table	Table	Overflow	Single page	Navegation	Shared		✓
11	*Cuiabá*	Detailed	Data source	List	List	Overflow	Multiple pages	Navegation	Shared		✓
12	*Campo Grande*										
13	*Belo Horizonte*	Detailed	Data descrip	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
14	*Belém*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4	✓
15	*João Pessoa*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,4	✓
16	*Curitiba*	Detailed	Update info	Detailed vis	Table	Overflow	Multiple pages	Navegation	Shared		✓
17	*Recife*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4	✓
18	*Teresina*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
19	*Rio de Janeiro*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4,5	✓
20	*Natal*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
21	*Porto Alegre*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
22	*Porto Velho*	Detailed	Data source	Detailed vis	Table	Overflow	Multiple pages	Exploration	Semantic	1,3	✓
23	*Boa Vista*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
24	*Florianópolis*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
25	*São Paulo*	Detailed	Update info	Detailed vis	Table	Overflow	Multiple pages	Navegation	Shared	1,2,4	✓
26	*Aracaju*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
27	*Palmas*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓

Table 3. Content and composition dashboard design patterns of the budget open portals of states in Brazil. The first line refers to the federal budget open data portal. Also shown if the portal features a dashboard and a query interface, and dashboard genre: (1) Static, (2) Analytic, (3) Infographic, (4) Repository, and (5) Embedded mini-dashboards.

Nº	**States**	**Content dashboard design patterns**			**Composition dashboard design patterns**					**Dashboard**	**Query interf.**
		Data	**Meta Data**	**Visual repres.**	**Page layout**	**Screenspace**	**Structure**	**Interaction**	**Color**		
0	*Brazil*	Filtered	Data source	Detailed vis	Detailed vis	Overflow	Multiple pages	Exploration	Shared	1,2,3,4,5	✓
1	*Acre*	Filtered	Data source	Detailed vis	Table	Overflow	Single page	Exploration	Shared	1,2,4	✓
2	*Alagoas*	Filtered	Data source	Detailed vis	Table	Overflow	Single page	Exploration	Shared	1,2,3,4	✓
3	*Amapá*	Detailed	Data source	Detailed vis	Table	Overflow	Parallel	Exploration	Semantic	1,2,4	✓
4	*Amazonas*	Filtered	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
5	*Bahia*	Detailed	Data descrip.	Detailed vis	Stratified	Overflow	Multiple pages	Exploration	Semantic	1,3,4,5	✓
6	*Ceará*	Detailed	Data source	Detailed vis	Stratified	Overflow	Single page	Exploration	Semantic	1,2,3,4,5	✓
7	*Distrito Federal*	Detailed	Data descrip.	Detailed vis	Stratified	Overflow	Multiple pages	Exploration	Semantic	1,2,3,4,5	✓
8	*Espírito Santo*	Detailed	Data descrip.	Numbers.	Stratified	Overflow	Multiple pages	Exploration	Shared	1,2,3,4	✓
9	*Goiás*	Detailed	Data descrip.	Detailed vis	Stratified	Overflow	Multiple pages	Exploration	Semantic	1,3,4,5	✓
10	*Maranhão*	Detailed	Data source	Table	Table	Overflow	Single page	Navegation	Shared		✓
11	*Mato Grosso*	Detailed	Data source	List	List	Overflow	Multiple pages	Navegation	Shared		✓
12	*Mato Grosso do Sul*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
13	*Minas Gerais*	Detailed	Data descrip.	Table	Table	Overflow	Multiple pages	Navegation	Shrared	1,2,3,4	✓
14	*Pará*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3	✓
15	*Paraíba*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4,5	✓
16	*Paraná*	Detailed	Update info.	Detailed vis	Table	Overflow	Multiple pages	Navegation	Shared		✓
17	*Pernambuco*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4,5	✓
18	*Piauí*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4	✓
19	*Rio de Janeiro*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
20	*Rio Grande do Norte*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared	1,2,4	✓
21	*Rio Grande do Sul*	Detailed	Data source	Detailed vis	Table	Overflow	Multiple pages	Navegation	Shared	1,2,3,4	✓
22	*Rondônia*	Detailed	Data source	Detailed vis	Table	Overflow	Multiple pages	Exploration	Semantic	1,2,4	✓
23	*Roraima*	Detailed	Data source	Detailed vis	List	Overflow	Multiple pages	Exploration	Shared	1,3,4	✓
24	*Santa Catarina*	Detailed	Data source	Detailed vis	Table	Overflow	Multiple pages	Navegation	Shared	1,3,4	✓
25	*São Paulo*	Detailed	Data source	Detailed vis	Table	Overflow	Multiple pages	Exploration	Semantic	1,4	✓
26	*Sergipe*	Detailed	Data source	Table	Table	Overflow	Multiple pages	Navegation	Shared		✓
27	*Tocantins*										

Table 4. Design principles followed by budget open data portals of states' capital cities in Brazil. The first line refers to the federal budget open data portal. P1: Pick meaningful metrics; P2: Collect accurate and precise data; P3: Ensure your data makes sense; P4: Consider the audience; P5: Use the best visualization practices; P6: Use the correct type of chart; P7: Provide easy-to-use tools; P8: Clear presentation; P9: Provide context and data interpretation support; P10: Think about data literacy levels; P11: Ensure data is up to date; P12: Allow access to data source; P13: Check for personal data/outliers; P14: Interaction support; P15: Ensure feedback support; P16: Customization. Also shown dashboard genre: (1) Static, (2) Analytic, (3) Infographic, (4) Repository, and (5) Embedded mini-dashboards.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	Dashboard	Query interface
Brazil	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	1,2,3,4,5	✓
Rio Branco	✓	✓					✓					✓	✓	✓	✓		1,2,4,5	✓
Maceió	✓					✓					✓	✓	✓	✓				✓
Macapá	✓	✓	✓				✓					✓	✓	✓				✓
Manaus	✓	✓					✓					✓	✓	✓				✓
Salvador	✓	✓	✓			✓	✓				✓	✓	✓	✓			1,2,3,4	✓
Fortaleza	✓	✓					✓					✓	✓	✓				✓
Brasília																		
Vitória	✓	✓	✓				✓					✓	✓	✓			1,2,3,4,5	✓
Goiânia	✓	✓					✓				✓	✓	✓	✓				✓
São Luís							✓					✓	✓	✓				✓
Cuiabá												✓	✓					✓
Campo Grande																		
Belo Horizonte	✓	✓											✓	✓				✓
Belém	✓	✓	✓				✓					✓	✓	✓			1,2,3,4	✓
João Pessoa	✓	✓					✓				✓	✓	✓	✓			1,2,4	✓
Curitiba	✓		✓			✓	✓				✓	✓	✓	✓				✓
Recife	✓		✓			✓	✓				✓	✓	✓	✓			1,2,3,4	✓
Teresina	✓						✓					✓	✓	✓				✓
Rio de Janeiro	✓						✓				✓	✓	✓	✓			1,2,3,4,5	✓
Natal	✓	✓					✓					✓	✓	✓				✓
Porto Alegre	✓	✓					✓				✓	✓	✓	✓				✓
Porto Velho	✓	✓			✓	✓	✓	✓				✓	✓	✓	✓		1,3	✓
Boa Vista	✓	✓	✓								✓	✓	✓	✓				✓
Florianópolis	✓	✓									✓	✓	✓	✓				✓
São Paulo	✓	✓				✓	✓				✓		✓	✓			1,2,4	✓
Aracaju	✓	✓					✓				✓	✓	✓	✓				✓
Palmas	✓										✓	✓	✓	✓				✓

Table 5. Design principles followed by budget open data portals of states in Brazil. P1: Pick meaningful metrics; P2: Collect accurate and precise data; P3: Ensure your data makes sense; P4: Consider the audience; P5: Use the best visualization practices; P6: Use the correct type of chart; P7: Provide easy-to-use tools; P8: Clear presentation; P9: Provide context and data interpretation support; P10: Think about data literacy levels; P11: Ensure data is up to date; P12: Allow access to data source; P13: Check for personal data/outliers; P14: Interaction support; P15: Ensure feedback support; P16: Customization. Also shown dashboard genre: (1) Static, (2) Analytic, (3) Infographic, (4) Repository, and (5) Embedded mini-dashboards.

States	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	Dashboard	Query interface
Acre	✓	✓					✓					✓	✓	✓			1,2,4	✓
Alagoas	✓					✓	✓				✓	✓	✓	✓			1,2,3,4	✓
Amapá	✓	✓	✓				✓					✓	✓				1,2,4	✓
Amazonas	✓	✓										✓	✓	✓				✓
Bahia	✓	✓			✓	✓	✓				✓	✓	✓	✓			1,3,4,5	✓
Ceará	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓		1,2,3,4,5	✓
Distrito Federal	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	1,2,3,4,5	✓
Espírito Santo	✓	✓	✓			✓	✓				✓	✓	✓	✓			1,2,3,4	✓
Goiás	✓	✓	✓		✓	✓	✓				✓	✓	✓	✓			1,3,4,5	✓
Maranhão	✓						✓				✓	✓	✓	✓				✓
Mato Grosso	✓											✓	✓	✓				✓
Mato Grosso do Sul	✓	✓					✓					✓	✓	✓				✓
Minas Gerais	✓		✓				✓	✓			✓	✓	✓	✓			1,2,3,4	✓
Pará	✓						✓						✓				1,2,3	✓
Paraíba	✓	✓										✓	✓	✓			1,2,3,4,5	✓
Paraná	✓						✓					✓	✓	✓				✓
Pernambuco	✓	✓			✓	✓	✓	✓	✓		✓	✓	✓	✓			1,2,3,4,5	✓
Piauí	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓			1,2,3,4	✓
Rio de Janeiro												✓	✓					✓
Rio Grande do Norte	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓			1,2,4	✓
Rio Grande do Sul	✓	✓	✓			✓	✓				✓		✓	✓			1,2,3,4	✓
Rondônia	✓	✓	✓		✓	✓	✓	✓				✓	✓	✓			1,2,4	✓
Roraima	✓	✓	✓			✓					✓	✓	✓	✓			1,3,4	✓
Santa Catarina	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓			1,3,4	✓
São Paulo	✓						✓					✓	✓				1,4	✓
Sergipe	✓	✓	✓				✓				✓	✓	✓	✓				✓
Tocantins																		