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Experience in Creating Demographic Dashboards

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ABSTRACT: "Digital technologies are now actively utilized across all scientific disciplines, and demographic science is no exception. Demographers leverage both new data sources generated in the digital environment and advanced data processing methods based on machine learning and data mining. Additionally, a significant application of digital technologies is the development of interactive web applications, or dashboards, that present demographic data. These dashboards offer convenient access to information and can be utilized in both academic research and public administration."

KEYWORDS: population; demography; dashboards; Uzbekistan

INTRODUCTION

Digital technologies are now actively utilized across all scientific disciplines, and demographic science is no exception. Demographers leverage both new data sources generated in the digital environment and advanced data processing methods based on machine learning and data mining. Additionally, a significant application of digital technologies is the development of interactive web applications, or dashboards, that present demographic data. These dashboards offer convenient access to information and can be utilized in both academic research and public administration.

This article will begin by examining existing examples of demographic dashboards created by researchers and companies worldwide. Following this, we will propose a methodology for developing a dashboard that presents data on the Arctic population, along with a list of data sources utilized. Finally, we will explore the functionality and potential applications of the web application "Digital Twin of Uzbekistan's Population," which was developed using the proposed methodology.[1]

The use of data has become a standard expectation for education leaders and stakeholders when making difficult decisions. The essential problems are sifting through mountains of it effectively and communicating actionable, data-driven findings to diverse audiences. Given the increasing accountability demands, the increasing preponderance of data in digital form, and the growing ability to manipulate and analyze this data, there is an increasing interest in using data visualization to address these two information handling problems more effectively. Data visualization refers to the process of representing information in graphical form, enabling the user to see images that help understand the underlying meaning of the information. One common form of using data visualizations in educational arenas is to create dashboards that are used to present information from a variety of early childhood, K-12, and post-secondary areas.

The purpose of this paper is to introduce and describe key components of dashboard development. The first part of the paper provides an overview of dashboards, compares dashboards to scorecards, and discusses how dashboards are used in education. The second part of the paper provides a step-by-step guide and explanation of analytical techniques to develop effective demographic dashboards. The third and final section of the paper presents a case study. An increasing number of states have developed prekindergarten through 12th grade dashboards. These dashboards display and make available information that can be used to make informed decisions. Some of the benefits of dashboards include providing direction for decision making, bringing data together to identify trends and demographic issues for further analysis, and linking strategic plans and objectives. Future uses of dashboards as part of school reform initiatives will continue to use the state-level dashboards as a starting point.

[1] https://uiec.ru/wp-content/uploads/2023/06/%D0%B4%D0%B5%D0%BC%D1%84%D0%BE%D1%80%D1%83%D0%BC_2023-1.pdf

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DASHBOARDS IN DEMOGRAPHIC SCIENCE

The term "dashboard" is a direct translation from English and lacks an exact equivalent in Russian. Consequently, the word "dashboard" has been borrowed and is commonly used by data scientists and specialists in digital technology.

Strategic. They help to assess the situation that has arisen in the business and find and fix problems. Often they are not detailed — they only demonstrate the achievement of goals and KPIs.

For example, the introduction of a dashboard that reflects the degree of satisfaction with the service will allow you to understand what affects customer loyalty and implement improvements. For example, think over new scripts or install a self-service terminal in the store.

Analytical. They contain a lot of information, sections and filters. They are used by managers to keep statistics, compare results, look for patterns and draw conclusions. They help to detect deviations from the planned results and find their causes.

For example, a company can create a dashboard that will calculate product indicators: the number of sales, the share in the total turnover. Using this data, the head of the marketing department will be able to set a task for the active promotion of the "lagging" product.

Operating. Their task is to display the dynamics of data on a variety of business indicators, including ongoing processes. Such dashboards are used by ordinary employees to find out the latest data, for example, the balance on the account or the amount of a product in stock.

An example is the dashboards of web analytics services. They record site traffic, traffic sources, bounce rates, user behavior on the site, and other metrics. This data can be used by marketers, developers, or web designers. In a dashboard, data is organized to facilitate convenient interaction for the user. The integration of charts, tables, cartograms, and infographics, along with various controls, enables users to analyze and organize data in multiple ways. A dashboard serves as a practical tool for professionals, providing necessary data in an easily accessible format and allowing customization of its presentation. Dashboards are utilized in various fields, including business, science, and public administration.[2]

Demographic dashboards are tools specifically designed to analyze demographic data. A notable example is the interactive maps generated from the 2021 UK Census. These maps allow users to visualize various aspects of demographics, education, health, housing, and employment in England and Wales at the level of individual statistical observation sites, which can sometimes include just a few houses. Another common use for demographic dashboards is to present modeling and forecasting results. For instance, the Wittgenstein Center for Demography and Global Human Capital in Austria has developed a web application that forecasts the dynamics and educational composition of the world's population up to the year 2100 based on five different scenarios.

The development of demographic dashboards experienced significant acceleration during the COVID-19 pandemic, as timely information became crucial. In the early months of the pandemic, a dashboard created by Johns Hopkins University garnered considerable attention for publishing data on infections and deaths worldwide. The University of Northern Iowa also developed dashboards on the ArcGIS platform to display data regarding coronavirus infections and deaths across various countries and regions of Uzbekistan. In Russia, the Yandex dashboard emerged as the most recognized platform, providing data at both the country and regional levels. This includes statistics on infections, deaths, compliance with self-isolation measures in Russian cities, and the popularity of search queries related to the coronavirus. However, despite having extensive experience in creating demographic dashboards, there are currently no sufficiently elaborate solutions that cover the diverse aspects of demographic development in Uzbekistan.

METHODOLOGY AND DATA

Three methodological principles were employed in the development of the dashboard focused on the demographic development of Uzbekistan. First, the hierarchy of territories was taken into account. The Asian zone comprises territories of varying levels: municipalities, subjects of Uzbekistan, and the macro level. Most statistics were gathered at the local municipal level and then aggregated to higher levels, since in Uzbekistan, nearly all aspects of life are influenced by the distance of territories from major settlement centers. These trends are effectively illustrated in the "Atlas of Population, Society, and Economy in Uzbekistan." In the dashboard, each district is represented by its boundaries on map diagrams, with each settlement shown by its geographical coordinates.

[2] https://uiec.ru/wp-content/uploads/2023/06/%D0%B4%D0%B5%D0%BC%D1%84%D0%BE%D1%80%D1%83%D0%BC_2023-1.pdf

Third, the dashboard integrates traditional and new data sources generated by digital transformation, referred to as digital footprints. Digital footprints encompass the results of social interactions facilitated by digital tools and spaces, as well as digital records of other culturally significant materials. They enable the collection of more detailed and up-to-date data on demographic processes. The primary sources of traditional statistics for the "Digital Twin of Uzbekistan's Population" include the Rosstat Database of Municipal Indicators and the results of population censuses conducted from 1939 to 2021. These statistics detail the movement of people via train and plane, alongside data from Yandex on morbidity, mortality, self-isolation, and search queries during the pandemic. The Research Data Infrastructure project also contributes information about resettlement. Together, these data sources enhance traditional statistics and provide a more comprehensive understanding of various demographic issues.

The dashboard, "Digital Twin of Uzbekistan's Population," utilizes a client-server browser architecture. It is built on the Dash web framework using the Python programming language. Most graphs and cartograms are created with the Plotly package, while graph visualizations utilize Cystoscope, NumPy, and pandas for data analysis. For network data structures, NetworkX is implemented, and spatial data analysis is conducted using GeoPy. User interaction with the dashboard is managed through the Nginx web server and the Gunicorn WSGI server.

Thus, the demographic situation is a complex and multifaceted process that requires a comprehensive analysis. Understanding demographic trends and their impact on the health system and social services is a prerequisite for effective management of these areas. In the context of population ageing, declining birth rates and migration processes, health systems and social services must adapt to new challenges and ensure the availability and quality of medical services for all groups of the population. In conclusion, it can be noted that demographic pressure on health care and social services is an urgent problem that requires attention from the state, society and the scientific community.

LITERATURE REVIEW

The study, conducted by C. David and his research team, is based on the premise that demographic data visualization can offer tools for quickly disseminating, understanding, and interpreting data sets, and can facilitate evidence-based decision-making by expanding access to the necessary information.[3]

The result of Spencer Keller's research, the goal of GIS mapping exchange collaboration was to create operational dashboards for the library, combining data from the 2020 U.S. decennial census, the 2020 American Community Survey, and current student enrollment data from the Oregon Department of Education, along with data on their active library cardholders. The data for this dashboard was created using Esri's ArcGIS Pro and is hosted with the dashboard on ArcGIS Online. The dashboard is now being used to gain insight into the spatial distribution of active library cardholders and the demographics of the community they serve, to better inform library outreach, and to help the library apply for grants.[4]

The study, conducted by Sojung Yi, MD, and her team, is particularly useful for quality improvement initiatives because it captures common departmental issues, including delays in clinician interventions, inpatient admissions, and transfer rates. This digital tool helps to show how these operational factors impact our diverse patient populations. The dashboard ultimately enables the ED team to measure current performance, identify our weaknesses, and develop targeted interventions to address disparities in clinical care.[5]

An online dashboard created by Daphna Levine1* and colleagues provides a visual representation of these changes, making the data accessible to policymakers and planners. The tool's inclusion of environmental factors increases its applicability in identifying vulnerable populations and resilient communities during urban renewal. The user-friendly approach, which is compatible with existing planning tools, will help the article advance urban planning practice and meet community needs.[6]

To inform the development of the dashboard, the study examined data on exit type, reasons for exit, and employment outcomes for consumers leaving the program. The results showed differences in Competitive Integrated Employment (CIE) outcomes by region, race, and gender. In addition, other exit reasons, such as no longer being interested in services, not being

[3] Concannon D, Herbst K, Manley E Developing a Data Dashboard Framework for Population Health Surveillance: Widening Access to Clinical Trial Findings JMIR Form Res 2019;3(2):e11342 doi: 10.2196/11342

[4] Keller, Spencer, "Building Roseburg Public Library's Community Demographics Dashboard" (2022). *Masters in GIS Practicum Reports*. 1. https://pdxscholar.library.pdx.edu/geog_master_GIS_reports/1

[5] Designing and developing a digital equity dashboard for the emergency department
Sojung Yi MD, Caroline Burke MD, MPH, Amanda Reilly MD, MPH, Steven Straube MD, MBA, Joseph Graterol MD, Christopher R. Peabody MD, MPH First published: 30 June 2023 **https://doi.org/10.1002/emp2.12997**

[6] https://doi.org/10.3389/fbuil.2024.1405464

able to find a location, or being unable to contact people, are factors that could significantly reduce the number of cases, says Kevin Harris. [7]The standard of living of the population is a complex economic category that reflects the totality of the influence of various factors on the nature and volume of consumption of goods and services by the population, the maintenance of a certain lifestyle [Bobkov and Mstislavsky, 1996, 3; Ayvazyan, 2000, 1; Malikov, 2002, 8]. Equalization and ensuring a decent standard of living for citizens throughout the country is one of the priorities of the state. The main factors that have a significant impact on the parameters of the standard of living of the population of different regions are the following:

1) Natural and climatic conditions of the territory, since differences in them form different needs for certain goods and services [Ayvazyan, 2012, 2];

2) Territorial distribution of the main productive forces, which determines the need for labor force, which subsequently determines employment, wages and incomes of the population.

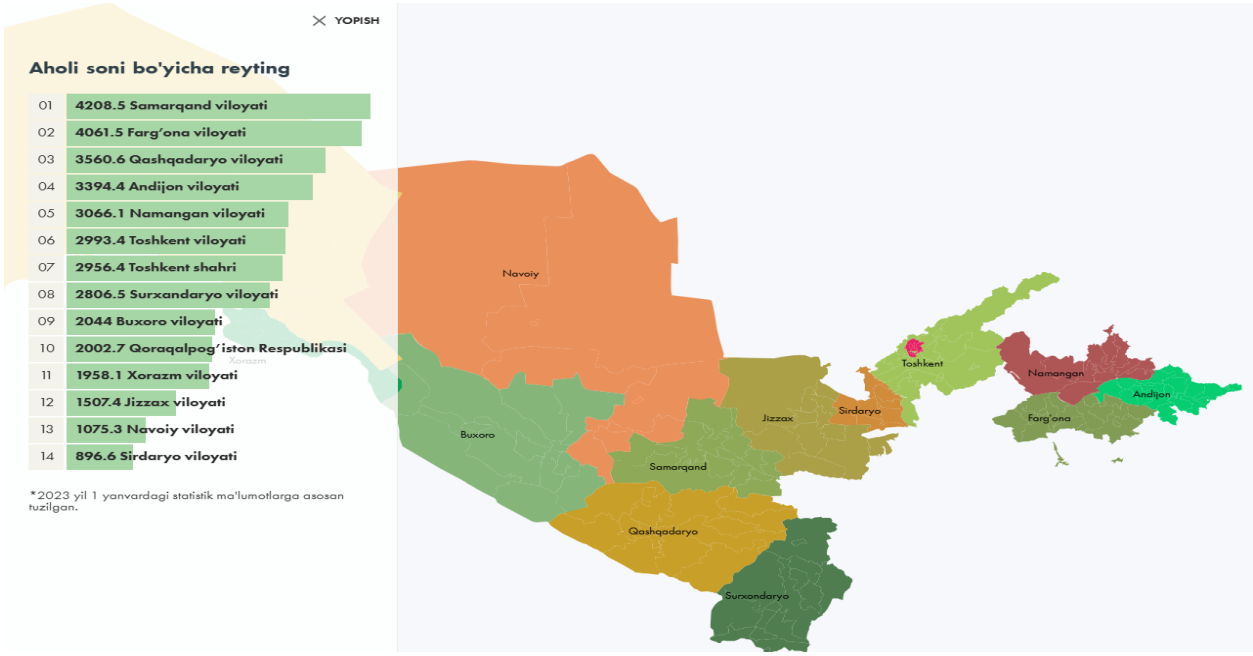
3) Development of the social infrastructure of the territory - meeting the needs of citizens in education, health care, cultural, recreational, sports and health services [Bobkov, Volgin, Akimov, 2014, 6; Naberezhnaya, 2010, 11].

4) Socio-demographic factors - the size of the population, its sex and age structure, the level of demographic burden on the able-bodied population, the level of external and internal migration; the quality of the population itself - the level of health, education, professional competencies that form the so-called "human capital", and are part of various qualimetric indices, for example, in the Human Development Index (HDI) [The Quality..., 1993, 14; United Nations., 2005, 15].

Other professor`s theory: The evaluation participants were drawn from a diverse group of users working at the site (n=20), comprising of community members, nurses, scientific and operational staff. Evaluation demonstrated high usability for the dashboard across user groups, with scientific and operational staff having minimal issues in completing tasks. [8]

DASHBOARD "DIGITAL TWIN OF THE UZBEKISTAN`S POPULATION"

Let's consider the functionality of the "Digital Twin of the Uzbekistan`s Population" dashboard. The main page of the site is devoted to the Asian zone of the Russian Federation (Fig. 1). In the "Indicators" tab, it is possible to build interactive background cartograms for the selected indicator for 2020–2030. The color jackal is customizable. In the Multivariate Analysis tab, the user can use a bubble chart to visualize four metrics at the same time. Two of them are responsible for the position of the circle horizontally and vertically, the third for its size, and the fourth for the color. A choice of logarithmic scales and trend line construction is available. The tool is designed to identify patterns between indicators.



https://demografiya.uz/vizual-statistika/

[7] Harris, K. (2021). Developing a Dashboard: Preliminary Steps and What We Learned. *Rehabilitation Counselors and Educators Journal*, *10*(2). https://doi.org/10.52017/001c.28186

[8] Concannon D, Herbst K, Manley E "Developing a Data Dashboard Framework for Population Health Surveillance: Widening Access to Clinical Trial Findings" JMIR Form Res 2019;3(2):e11342 doi: 10.2196/11342

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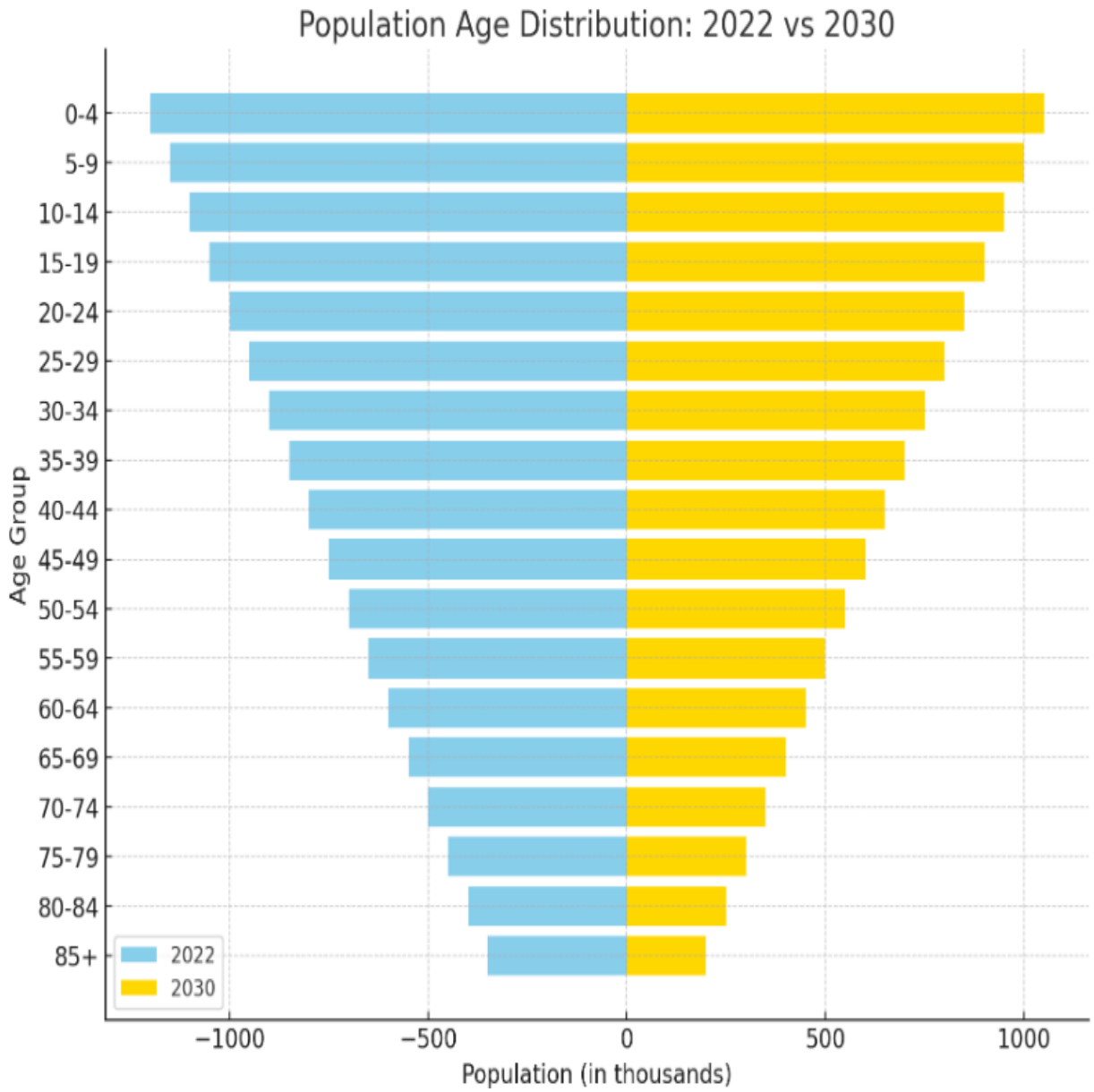
In the "Clustering" tab, *the k-means method is used to cluster municipalities by one or more indicators. Standard data scaling is used. To assess the quality of the model, the sum of the squares of the distances from the initial points to the centers of the clusters closest to them is calculated (*the inertia function of the *scikit-learn* package). The lower the value, the better the model. In the "Forecast" tab, you can extrapolate any indicator for the selected Arctic territory. The degree of the polynomial that approximates the value of the indicator is adjusted. It is possible to select the interval of values taken into account in the forecast. This allows, for example, to exclude from consideration the values affected by the COVID-19 pandemic. In the "Settlement" tab, interactive maps of the settlement of the Arctic are available. The first reflects all settlements by type and population. The second and third are the ethnic composition (the largest and second most populous nationalities in each municipality). Animation of urban settlement in the Arctic zone is also available there.



www.stat.uz

The study of migrations is based on the network (graph) approach [2, 12]. The 'Migration' tab displays an interactive graph of migration movements in the Uzbek people based on the 'Virtual Population of Uzbekistan' project. The user can choose the graph layout scheme and the minimum reflected value of the migration flow. The graph is then automatically rebuilt. At the bottom, you can see the number of times you have traveled through the selected node or thread. In the "Transport" tab on the map, the movement of passengers on trains and planes is visualized according to the Tutu.ru service. The user can choose the displayed modes of transport and detail information for each settlement.

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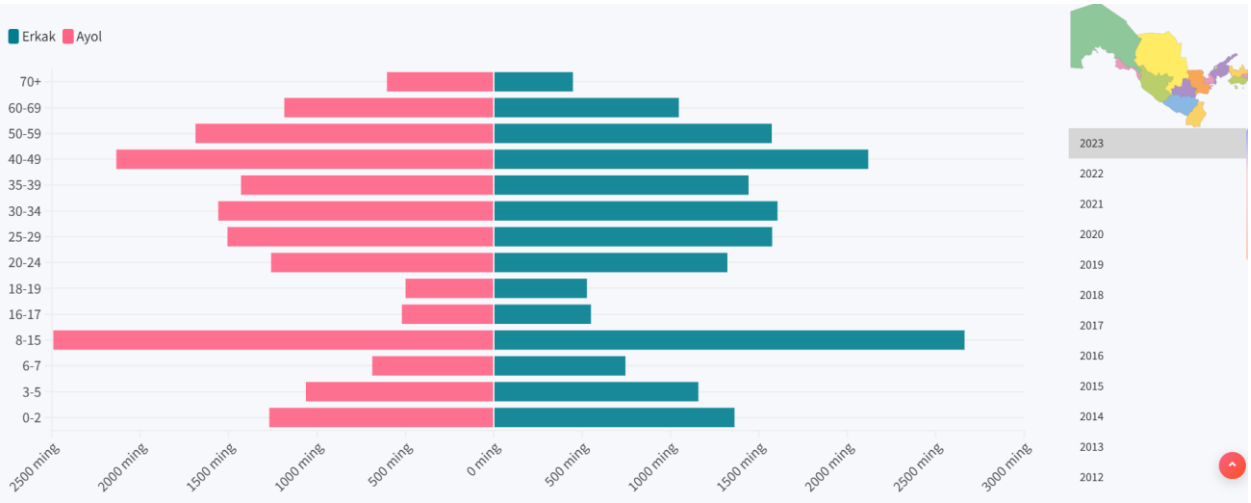


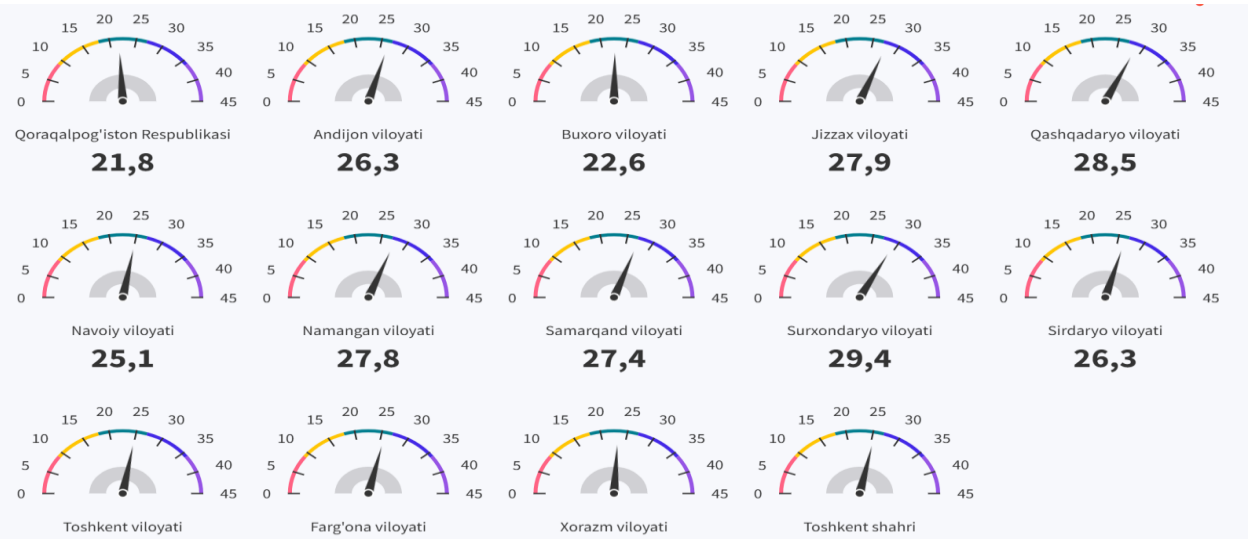
https://demografiya.uz/vizual-statistika/

At the top of the "Science and Education" tab, there is a diagram with information on the Comprehensive Publication Performance Score (CAP) for scientific organizations in the Russian Arctic since 2012, excluding branches according to the scientific electronic library eLIBRARY.RU. The KBPR characterizes the publication effectiveness of a researcher and is calculated taking into account the quantity and category of scientific publications using the fractional counting method (a division of the author's contribution to the scientific result if the publication was prepared by several authors and from different organizations). The lower part shows the number of students at Asian universities since 2014

$a + (b \cdot 0.25) + ((c + d) \cdot 0.1)$,

where a is the number of full-time students; b is the number of full-time and part-time (evening) students; c is the number of part-time students; d is the number of external students.

The "Pandemic" tab presents a time series of COVID-19 pandemic indicators for the Asian regions and Russia. These are absolute and relative indicators of infections and deaths, the self-isolation index, and the dynamics of search queries in the Yandex system related to the pandemic [13]. The self-isolation index characterizes the change in the activity of users of Yandex services on the streets of cities during the pandemic. The higher the score, the fewer people there are on the streets. A value of 0 points corresponds to the level during rush hour on a weekday before the pandemic, and 5 points corresponds to the value at night. The analysis of search queries was carried out for 15 key phrases (markers) that users often search for in conditions of self-isolation or illness: "antibodies", "second wave", "call an ambulance", "home delivery", "how not to get infected", "buy an antiseptic", "buy a mask and respirator", "treatment of coronavirus", "lost sense of smell", "pulse oximeter and saturation", "take a test", "do a CT scan", "symptoms of coronavirus", "what to do at home", "what to do if an ambulance does not come". These data can be used to predict morbidity [14]. The value for the Arctic regions was determined as a population-weighted average.



https://demografiya.uz/vizual-statistika/

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The largest section "Profiles of Territories" includes 85 Internet pages for the number of territories of Uzbekistan: The demographic profile of each territory consists of 4 parts. The profile begins with a brief description of the municipality, including an estimate of the population according to the last census and as of the current date. Then an interactive graph is presented, where you can see the dynamics of the selected indicator and compare it with the values of the indicator in other Arctic territories. Below is a table of urban population settlement - the population of all cities and urban-type settlements located within the territory, from 2010 to 2023, according to population census data. The next elements of the profile are the age pyramid by one-year age groups and the diagram of the educational composition of the population. At the bottom of the profile is a table with the values of the main demographic indicators. For each indicator, the rank among the territories of the Russian Arctic is indicated. If the built-in functionality is not enough to solve a problem, the user can download the source code of the dashboard and all the datasets used from the repository on GitHub1. With their help, you can modify all elements and perform an in-depth analysis of the data.

CONCLUSION

The study showed that dashboards have already become widespread in demographic research. As part of the study, the "Digital Twin of the Uzbekistan`s Population" was implemented, an interactive website containing detailed data on the population of the Uzbekistan, down to the municipal and settlement levels. The dashboard covers such issues as the size, dynamics and composition of the population, settlement, natural and migration movement, labor and employment, transport movements, science and education, and the impact of the pandemic. From the point of view of state and municipal management, the demographic profiles of regions and territories, reflecting information on the demographic situation, are of the greatest interest. The demographic dashboard for Uzbekistan will be useful for analyzing current demographic trends and planning strategies in the field of health, education and social security. Such a dashboard will allow public authorities and stakeholders to receive operational information about the population, make informed decisions and anticipate future demographic changes.

In conclusion, demographic pressures on health and social services are an urgent and multifaceted problem that requires an integrated approach. It is necessary to take into account not only medical aspects, but also social, economic and cultural factors that affect the quality of life of the population. The readiness of society and the state for changes, as well as the active participation of citizens in solving these issues, can be the key to successfully overcoming demographic challenges. It is important that all stakeholders – government agencies, medical institutions, social services and citizens themselves – work in one direction, creating conditions for the health and well-being of everyone, regardless of their age and health status.

This book aimed to introduce various analytical techniques for creating effective demographic dashboard in the context of big data and discuss the essence of these techniques in the context of the demographic risk management. The purpose of this effort is to develop an integrative analysis and modeling system in practice to create effective dashboard to depict hidden information between the socioeconomic and demographic variables, and overall demographic risk associated with social issues. The challenges still lay ahead on how to develop and extend techniques in applying to big data in demographic studies, involve with domestic or international demography data, the number of variables, real-time powerful visual capabilities, and accurate quantitative and qualitative interactions as well as predictive and policy analysis.

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