Visualization of demographic statistical data

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Abstract. In this publication, the authors address the content and objectives of demographic data visualization, generalize the most common techniques and tools for demographic data visualization, and share their own experience of testing various statistical visualization practices, namely World Population Dashboard of United Nations Population Fund and Population Reference Bureau. Special emphasis is placed on the implementation of Trendalyzer software, developed by the Swedish Gapminder Foundation, and the experience of demographic statistics visualization via interactive infographics made by Oxford Martin School (a structural unit of the Department of Social Sciences at Oxford University). The presented article evaluates the contribution to the visualization of statistical data made by such Ukrainian organizations as State Statistics Service, public organization “Ukrainian Center for Public Data”, BusinessViews and Top Lead. Outlining the advantages and disadvantages of various visualization practices, the authors argue that “dry” statistics being represent by means of visualization tools such as Trendalyzer and Our World Data may constitute a clear and expressive language of convincing facts that contribute to a holistic demographic worldview.

1. Introduction
1.1. The problem statement
Professionals specializing in the population issues permanently deal with challenges related to comprehension, systematization, analysis, generalization and presentation of large data sets that characterize the number, composition, movement and location of the population in terms of a separate administrative-territorial unit (country, county, region) and globally. Statistical data are dynamic, thus their presentation in text format complicates the cause-and-effect identification, and establishment of trends and patterns existing between demographic phenomena and processes. Visualization itself particularly facilitates the process of analysis, presentation and comprehension of complex demographic data, as human brain perceives and processes visual information faster and better than textual one [1].

The scientific literature review indicates that the research topic we are studying is not new. Several attempts have been made to address particular aspects, that is: data visualization in sociology [2]; exploring the demographic history of populations with enhanced Lexis surfaces [3]; reaching the potential of visualization of statistical data on the POWER BI platform [4]. There is a growing body of literature that recognizes the importance of data and statistics visualization
to a wide audience [5], and explores some aspects of visualization of statistical and scientific data [6]. Existing research recognizes the critical role played by methods of visualization and their perception [7]; and demographic data visualization [8].

More recent attention has focused on manuals and guides, i.e. Open manual on open data [9]; Pro Tableau: a step-by-step guide [10]; and 10 Demographic Infographic Templates to Share Population Data and More [11] and others.

Meanwhile, the analysis of the data visualization background highlights not only significant breakthrough in comprehension of the issue studied, but also indicates certain gaps in some important aspects of it. On the one hand, according to [8], good visualization, applied in a scientific context, improves the understanding of the underlying data without sacrificing truth for the sake of beauty. “Visualizations can be employed to efficiently explore and discover patterns in demographic data, to help viewers gain a better understanding of magnitudes, intensities, durations, changes, and differences, and to communicate these to large audiences” [8]. On the other hand, the current state of data visualization often does not meet societal needs, as the amount of statistical information is rapidly growing and constantly changing. It follows from the above that it is not enough for the visualization tools to visualize and illustrate the data, as it is also essential to update the information to the current state correspondingly.

1.2. The objective of the article
This publication overviews the current state and the analysis of the authors experience of visualization of demographic data. To achieve the declared objective, we apply the following research methods: systematization and analysis of the scientific literature and the method of visualization, which is considered as a systematic, rule-based, dynamic and / or static graphical representation of information, which helps to identify cause-and-effect relationships between demographic phenomena and processes.

2. Results and discussion
2.1. Visualization techniques
Visualization is a graphical presentation of information, which can concisely represent large arrays of data in an image. There are many visualization techniques presently, among the most common are graphs, diagrams, spectrograms, tables, infographics, charts, interactive storytelling, maps and cartograms, etc. Whatever the visualization technique, the data “speak” itself. The choice of a specific data visualization technique depends on the specifics of the data to be illustrated and the purpose of the visualization.

The advantages of visualization are:

• emphasis on different aspects of the data;
• analysis of a large data set complex in structure;
• reduction of human information overload and focus of human attention;
• unambiguity and clarity of the derived data;
• allocation of the links and relationships contained in the information [12], [13].

We can define the following visualization objectives based on the scientific literature review:

• to represent visually quantitative information in schematic form;
• to present data in an objective and relevant way without distortion and curvature (each visual indicator is presented unambiguously);
• to generate automatically visual product from the data set;
• to present predominantly the most significant elements correctly (not to overload the user’s attention with redundant information);
2.2. Visualization tools

Common knowledge is talking about the complex in a simple and accessible form is not an easy task, that is why talking statistics so they come to life, to observe the cause and effect of demographic phenomena and processes beneath the numbers, to reveal trends and patterns, makes an extremely difficult task. Nevertheless, digital technologies presently offer many tools for data visualization. Let us consider some of them in more details.

Addressing the interactive visualization of relevant demographic data, the World Population Dashboard of United Nations Population Fund and the Population Reference Bureau are worth referring to.

World Population Dashboard [14] is an interactive dashboard that demonstrates population data, key demographics globally, regionally and locally (by country). Presented data provided by the United Nations Population Fund and other UN agencies is updated annually and can be downloaded in PDF and XLSX formats. The main indicators to filter information are Population, Maternal and Newborn Health, Family Planning, Education, Fertility, Life Expectancy, Harmful Practices.

The Population Reference Bureau (PRB) [15] is a private non-profit organization founded in 1929 that specializes in collecting and providing statistics necessary for research and / or academic purposes related to the environment, health and population structure. The PRB website presents relevant demographic information summarized in the World Population Data Sheet and visualized in the form of interactive maps, charts, graphs, etc.

The advantages of the above mentioned web resources are the relevance of information, its prompt updating, free of charge access to data, the information dissemination capacity, convenient format back-up. However, the proposed mode of data presentation fails retrospective analysis, a choice of user-friendly format for data presentation, etc. The latter opportunities are extensively provided in the Trendalyzer software and on the Our World in Data website.

Trendalyzer [16]. The software was developed at the initiative of Hans Gösta Rosling, who is a Swedish physician, a professor at the Carolingian Institute of International Health, and a founder of the Gapminder Foundation. Hans Gösta Rosling, being an internationally acclaimed TEDster and statistician, introduced an extremely powerful web service for retrospective visualization of the global, regional and country statistics by means of Google Motion Charts. The current version of Trendalyzer – Gapminder World – is a visually attractive product that provides users with socially relevant information. The amateur users can take advantage of such tools as Bubbles, Maps, Trends, Ranks, Ages, Dollar streer, etc., whereas professional users may benefit from visualization of statistics with their own data input to the Gapminder Tools Offline. Trendalyzer software components, including the Flash-based animation charting gadget, are currently available for public use as part of the Google API visualization. The picture below is an example of demographic data visualization via Gapminder World using Bubbles technology – an interactive bubble chart (figure 1, figure 2).

In the above example diagram, bubbles show several variables by default: two numerical variables on the X (number of children per woman) and Y (world population), bubble size (country population) and bubble color (region). The time variable controlled by a slider or a so-called timeline reflects the retrospective and projected development of a demographic phenomenon or process. Thus, a user, moving along the timeline, can observe the dynamics of the total fertility rate in the interim between 1800–2021, as well as the demographic forecast until 2100. The analysis of interactive data permits the characterization of the main quantitative indicators of birth rate, proving population birth rate to be the main driver of demographic development. Bubble diagram let identify the main factors effecting the birth rate; reveal the
Figure 1. Demographic forecast of the dynamics of the total fertility rate.

Figure 2. The comparative analysis of the total birth rate of distinct countries.

historical peculiarities of changes in this process; and analyze current demographic trends. The software can filter data and thus perform a comparative analysis of territorial features of fertility and its indicators globally and regionally (figure 3). Interactive graphs, maps, ratings of global demographic processes, proposed by Gapminder contribute to the change in perception of world development and help to overcome the “planetary ignorance”. In his interview, Hans Gösta Rosling emphasizes that Gapminder World exposes the world as it is, not as it is thought to be. “When people see the world to be the same as it was 10 or 50 years ago, it means that they see neither the direction in which we are all moving, nor the speed of change, nor the potential for development” [13].

Our World in Data [17]. The visualization of demographic statistics via interactive infographics from The Oxford Martin School at the University of Oxford is equally interesting and exciting.

Our World in Data is the result of collaboration between the non-profit Global Change Data Lab and Oxford University researchers who study global human problems based on empirical analysis of global statistics. The website provides data visualized in the form of numerous
interactive graphs, maps, tables on topics, grouped into 11 sections: Demographic Change; Health; Food and Agriculture; Energy and Environment; Innovation and Technological Change; Poverty and Economic Development; Living conditions, Community and Wellbeing; Human rights and Democracy; Violence and War; Education and Knowledge; Sustainable Development Goals Tracker.

Among the advantages of Our World in Data are the following:

- analytical information is demonstrated by various visual tools – tables, graphs, charts, maps;
- convenient interactive format for presenting the same information enables the dynamic nature of the studied demographic phenomena and processes to be reproduced;
- different levels of data visualization (global, regional, local) (figure 3);
- extension of the CCBY license for the use of visualized products (graph, table or map) which allows to adapt the information conventionally;
- the implementation of statistical reports of authoritative world organizations (United Nations Population Division, Food and Agriculture Organization of the United Nations, World Bank, Gapminder and others) as sources for creation of visual products;
- tables, graphs and maps are available in several formats (Image PNG, Vector graphic SVG, Full data CSV);
- visualized information can be disseminated on social networks (Twitter, Facebook) and site embedded.

In addition, the site offers explanations, comments and some instructions on how to use the interactive graphs, tables and maps.

We might suggest the following work procedure with the content available in the World Population Growth section.

The analysis of the content of interactive maps presented in this site section leads to the conclusion that the peak of world population growth is characteristic for the middle of the last twentieth century. Comparative analysis of the set of maps responds to a number of questions, including:

**Figure 3.** Natural population growth: global demographic forecast until 2050 (left), Natural population growth of the Europe region with illustrations of data for each country (right).
• How have natural growth and population growth changed in different regions of the world with times?
• What is the demographic forecast for the dynamics of natural growth and population growth?
• Which regions of the world and which countries demonstrate the highest and lowest natural increase?
• Why is natural growth the highest in Africa? Will this trend continue in the near future and why?
• What year was the negative natural increase recorded in? Why?
• Why is population growth declining every year?
• What are the reasons for countries with the same population growth rates in the last century (such as India and Nigeria) to grow population at different rates now?

Thus, a convenient interactive format for presenting the same information makes it possible to reproduce the dynamic nature of the studied demographic phenomena and processes (figure 4).

![Figure 4. Population by age bracket with UN projections World and Ukraine.](image)

The data visualization by Our World in Data covers not only large amounts of information, but also makes the perception of complex information more comprehensive, the comparison of quantities faster, and the identification of data patterns easier. For instance, the analysis of Population by age bracket with UN projections, World and Population by age bracket with UN projections, Ukraine (figure 5) lets trace age-related historical estimates of the population within 1959–2020 based on UN scenarios with average birth rates. Moreover, in order to detect the content of the current demographic trend, there is no need to compare the figures, as the nature of the dynamics of the studied demographic process is apparent. The salient feature of the data visualized with Our World in Data tools is persuasiveness, as such visualization format provides an objective outlook on age imbalances in the population and instant assessment of the ratio of children, people of reproductive age and the elderly. Regardless of the visualization technique used in Our World in Data, the data presented are objectified which is of extreme importance.

Consequently, our experience of practical testing Gapminder World and Our World in Data in delivering the courses of Population Geography and Fundamentals of Demography convincingly proves their reliability and feasibility in use, as exploiting the software makes it possible to:

• systematize and visualize data;
• present data in the form of simple and visual animation;
• receive the latest information, promptly observe the dynamics of data;
• publish data in the necessary hierarchy, carry out data comparative analysis;
• optimize the study of large data sets, highlight the most important ones;
• compare blocks of information, receive information in a customized form quickly.

The most important thing about the software observed is that “boring” statistics become clear, vibrant, eloquent, impressive and fascinating.

In Ukraine the state of demographic data visualization is not up to the mark compared to the Gapminder World and Our World in Data, presented above, despite the fact that the population is studied thoroughly and comprehensively. Systematic demographic research is carried out primarily on the basis of Ptoukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine. The latter is a reputable scientific institution in the international scientific space, which collaborates with a number of international organizations and foreign scientific institutions (UNDP, UNFPA, UNICEF, European Commission, The World Bank, ILO, IOM, World Health Organization, National Institute for Demography of France, Max Planck Institute for Demographic Research and others). Meanwhile, the rapid growth of available data overelaborates for professionals and users the search for the information necessary for grounded decisions. Therefore, there is a need to visualize a significant array of demographic data in an interactive format with up-to-date (systematically updated) content. As Seema Acharya and Subhashini Chellappan emphasizes “data visualization is visual communication” [10].

In Ukraine, among the individual organizations engaged in data visualization, we can mention the State Statistics Service, the Ukrainian Center for Public Data (UCDS) [18] and BusinessViews [19], all of which specialize in visual content. We would like briefly describe their contribution to the visualization of statistics.

The State Statistics Service, apart from presenting data via infographics, complimentary developed an application “Statistics in Smartphones”, which provides quick and convenient access to public information from the State Statistics datasets posted on the Unified State Web Portal of Open Data data.gov.ua. Convenient interface provides access to up-to-date statistical information; visualizes the information of data sets on selected parameters (indicators, classifications, territory and period); groups data sets by topics (branches of statistics); visualizes information in the form of graphs and histograms; download data sets to the “My sets” section; disseminate information via messengers and social networks.

UCD experts collect and systematize data sets; develop systems (geoinformation systems included) for convenient and visual presentation of data, online tools for working with data; prepare analytical reports based on comprehensive data analysis; share the data processing experience among the professionals and the public. Among the latest projects developed by the UCD is the interactive visualization “Mortality rate in Ukraine 2018–2020” (figure 5), which is distributed under a Creative Commons (CC BY) license, and can be copied and disseminated in any form or format and modified (edited, etc.).

BusinessViews release annual infographic guides (figure 6), which publish employment, business, finance, technology and other aspects of social life in a simple format and language of the target audience.

Apart from the above-mentioned data visualization services, there are available numerous cloud services for creating customized visual products in the varied formats, that is infographics, interactive maps, graphs, charts, etc.

Among the most popular services, which are equally suitable for obtaining a quick clear result as well as for advanced use, there are the following: Canva, Chart.js, ChartBlocks, Crossfilter, D3.js, DataHero, Datawrapper, Dygraphs, Ember Charts, FusionCharts, Google Charts,
Figure 5. Interactive visualization “Mortality rate in Ukraine 2018–2020”, developed by the Ukrainian Center for Social Data [18].

Figure 6. Infographics “Expenditures on higher education in Ukraine” (2018), presented by BusinessViews [19].

Highcharts, Infograph, InstantAtlas, Kartograph, Leaflet, Modest Maps, NVD3, OpenLayers, Plotly, Polymaps, Raw, Tableau Public, Timeline, Visual.ly, Visualize Free, ZingChart.

The analysis of the advantages and disadvantages of the latter is beyond the scope of this publication, but we consider their further perspective revision.
3. Conclusion
The scientific literature review and the analysis of the practical state of demographic data visualization have confirmed the conclusions that visualization is a powerful tool for presenting large data sets, with certain advantages and can be implemented using certain techniques (graphs, charts, spectrograms, tables, infographics, diagrams, interactive storytelling, maps and cartograms) and tools.

Among the currently available visualization tools, based on the authors’ positive practical experience, we can recommend the use of Trendalyzer (Gapminder), Oxford Martin School, World Population Dashboard (United Nations Population Fund) and World Population Data Sheet (Population Reference Bureau).

One of the findings of this research is that among the Ukrainian means of visualization of demographic data, the services developed by the State Statistics Service and the public organization “Ukrainian Center for Public Data” deserve attention. These tools can visualize the impact of various factors on the world’s population in the interactive mode, identify common demographic trends that occur globally, regionally or locally, reveal causal links between demographic phenomena and processes.

We anticipate the prospects for further research in the analysis of the advantages and disadvantages of a number of cloud services available for data visualization and coverage of the experience of their use aimed at demographic forecasting.

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