D. Alburez-Gutierrez, S. Aref, S. Gil-Clavel, A. Grow, D.V. Negraia, E. Zagheni. (2019). 'Demography in the Digital Era: New Data Sources for Population Research' in Arbia G., Peluso S., Pini A., Rivellini G. (eds.) *Book of Short Papers SIS2019*. Pearson.

Demography in the Digital Era: New Data Sources for Population Research

Demografia nell'era digitale: nuovi fonti di dati per gli studi di popolazione

Diego Alburez-Gutierrez, Samin Aref, Sofia Gil-Clavel, André Grow, Daniela V. Negraia, Emilio Zagheni

Abstract The spread of digital technologies and the increased access to the internet has contributed to the production and accumulation of unprecedented quantities of data about human behavior. Demographers, who have a long-standing interest in issues related to data and data quality, are in an ideal position to make sense of this new information. This paper discusses three ways in which the Data Revolution has created novel sources of data for demographic research. It discusses the unique technical and ethical challenges posed by these data sources and the opportunities they provide for understanding historical and contemporary demographic dynamics around the world.

Abstract *La diffusione di tecnologie digitali e la crescita nell'accesso ad internet hanno contribuito ad una produzione ed accumulo senza precedenti di dati sul comportamento umano. I demografi, che hanno avuto un interesse di lunga data su questioni relative a dati e qualità dei dati, sono in una posizione ideale per estrarre significato da queste nuove informazioni. Questo articolo discute tre modi in cui la 'Data Revolution' ha creato nuove fonti di dati per la ricerca demografica. L'articolo discute le sfide tecniche ed etiche create da questi dati e le opportunità che offrono per comprendere le dinamiche demografiche storiche e contemporanee.*

Key words: demography, digital data, social media, data revolution

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1 The Data Revolution: A New Data Paradigm in Demography?

Demography, the systematic study of population dynamics and the causes and consequence of compositional changes in populations, has always been a data-driven discipline. Administrators have used censuses to count (and tax) populations since ancient times. In modern societies, an interest in data characterized the development of the discipline of demography. For example, John Graunt identified London's 16th century 'Bills of Mortality' as a potential source of data for demographic analysis, ultimately resulting in the creation of life tables. We argue that demography is at the gates of a new data paradigm defined by the increased availability of population data produced or made available by digital technologies and the internet [6, 8]. The shift is part of the Data Revolution, the process through which the transition from analogue to digital electronic technologies has resulted in the accumulation of vast amounts of individual-level data (see Figure 1 for an illustration). The spread of the internet, the World Wide Web, and the Internet of Things, have accelerated this process, producing unprecedented data on society and human behavior [29].

This paper presents three innovative sources of data that have been made possible by the Data Revolution and explores their potential for conducting groundbreaking demographic research. First, digitization has helped improve access to existing data, such as censuses and population registers [33, 20], and bibliometric databases [12, 27]. Similarly, the advent of online peer-to-peer collaboration has created new resources, such as massive online genealogical databases [21], that can be used for studying intergenerational demographic processes. Second, demographers can now analyze digital traces left by internet users in platforms like Twitter [35] and Facebook (FB) [15] to study population dynamics. Finally, the Data Revolution has created new opportunities for collecting primary data using devices connected to the internet. Examples discussed in this paper include online surveys [7, 1], apps for registering time-use data [28], and internet advertising platforms [37, 9].

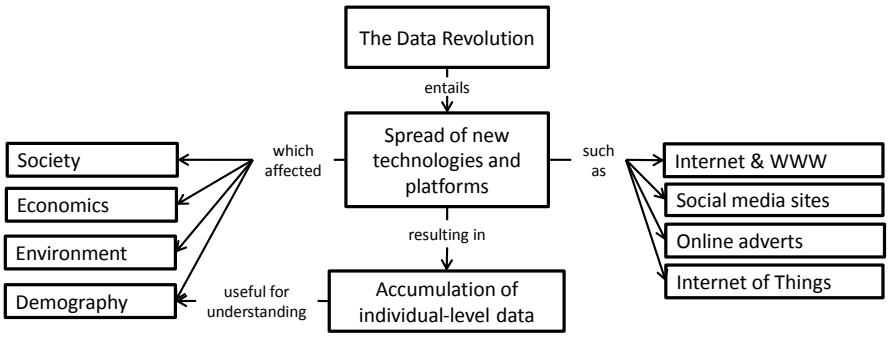

Fig. 1 The Data Revolution and new sources of data for demographic analysis.

1.1 Digitized and Crowd-sourced Data

Demographers and statistical agencies were quick to recognize the importance of digitizing paper-based demographic data. The digitization of censuses and population registers was pioneered by the Integrated Public Use Microdata Series (IPUMS), which now hosts the world's largest collection of demographic microdata.[1] In time, digitization enabled the creation of crucial data repositories for demographic research (e.g. the Human Mortality and the Human Fertility Databases[2] or digital national population registers). Nordic registers, for example, have been used to study intergenerational processes in fertility [22], health [5], mortality [4], and migration [33]. Most of the existing research focuses on Europe, but researchers increasingly acknowledge the potential of other population registers for conducting demographic research (e.g. East Asia [13] or North America [18]).

Bibliometric databases, such as Scopus [2], Web of Science [27], and Dimensions [32], are other examples of digitized sources with potential for demographic research. These databases contain data on millions of scientific publications produced each year, including author affiliation and addresses. Affiliation data can be used for analyzing scientific collaboration and mobility of researchers across countries [24, 3, 12]. Yet, using these data sources for migration research has limitations which require a careful interpretation of the results [2, 27]. Changes on author affiliation, for example, are not a perfect proxy for mobility since conducting and publishing research can be a lengthy process. Migration of researchers is likely to be underestimated because some movements are not represented in publications indexed in bibliometric databases. This calls for future research integrating bibliometric data with complementary data sources to resolve some of the methodological issues. Despite these limitations, bibliometric data sources offer substantial benefits [12, 27] compared to traditional data sources like surveys. These resources make research on migration of research-active scientists more cross-disciplinary, scalable, longitudinal, contemporary, and comprehensive.

Demographic data can also be crowd-sourced. Platforms like Geni.com and WikiTree have allowed thousands of amateur genealogists to collaborate in building large-scale online genealogical databases such as the *Familinx* database, which includes 86 million individual records from around the globe, with data that go back as far as the 17th century [21]. This particular database was scraped from Geni.com, a collaborative social network that allows users to find and verify family relations. Online genealogies are a promising resource because they cover long historical periods and are not restricted by national boundaries - on the downside, they are not representative samples and underrepresent Low- and Middle-Income countries (LMIC). Despite their potential, sound demographic research using these data is still missing, including methodologies for addressing systematic biases and generalizing the findings to larger populations [16].

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[1] www.ipums.org; www.international.ipums.org, accessed 28.02.2019.

[2] www.mortality.org; www.humanfertility.org, accessed 28.02.2019.

1.2 Digital Traces from Social Media

About half of the world's population are active internet users and many use social media platforms like FB and Twitter.[3] Demographic information on the users of these platforms can be used to perform demographic research in a timely manner. Social media data can also be used to study populations that would otherwise remain entirely out of reach [26]. Researchers can access FB and Twitter data using the platforms' Application Programming Interfaces (API), some of which have been designed for advertising purposes. The FB Marketing API gives access to aggregated population data (e.g., the number of FB users by sex and age in a given country who share certain interests), but not individual-level user data. Unfortunately, FB does not provide much detail about how these aggregate figures are estimated (e.g., how users are classified according to their interests, behavior, and demographic characteristics). Twitter, in addition to a Marketing API for aggregate-level summary information, allows researchers to query individual-level data from 'public tweets' (i.e. tweets not protected by the user).[4] Still, researchers can access information that users have agreed to share, including text and images from tweets, user names, and tweet locations. Having access to individual-level Twitter posts gives researchers the freedom to design and test different models and algorithms using primary data.

Previous studies have collected data using APIs to study contemporary social and demographic processes. FB data have been used to study access to digital technologies [15, 17], immigrant cultural assimilation [14], and to estimate migrant stocks [37]. Twitter data have been used to study migration flows [35], and monitor population health [10] and natural disasters [19]. The use of the FB and Twitter data has clear advantages, but also important drawbacks. A notable limitation is that social media data are generally not representative of the entire population. Recent studies have attempted to overcome this limitation by combining social media data, statistical models, and representative surveys [36, 37]. Another limitation is the lack of individual-level demographic data for Twitter users. Studies have addressed this limitation by using pattern recognition techniques to infer the demographic characteristics of users [34]. Nevertheless, there are clear benefits in using this new source of data. For instance, demographers and sociologists have been able to reach and study new populations, while statisticians and computer scientists have had the opportunity to test new models and algorithms. These examples show how the internet has created research opportunities that were unimaginable when social networking platforms were initially conceived, over 20 years ago.

[3] www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx, accessed 28.02.2019.

[4] help.twitter.com/en/safety-and-security/public-and-protected-tweets, accessed 28.02.2019.

1.3 New opportunities for collecting primary data

The Data Revolution has also created new opportunities for collecting primary data via the internet. Several studies have recruited participants for online surveys using social networking sites (e.g., FB and Twitter) and online labor markets (e.g., Amazon Mechanic Turk and Craigslist) [7]. Such platforms tend to have wide reach and often allow the targeting of individuals based on specific demographic characteristics, interests, and behaviors. This makes them attractive for both drawing convenience samples and recruiting members of hard-to-reach populations, usually at a lower cost than would be possible with traditional probability samples [1]. Of the existing platforms, FB has been the most popular, arguably because it (currently) has the largest number of users and the widest international coverage, and because it provides detailed information about user characteristics that can be used for targeting participants [7, 9]. In the existing studies using FB, recruitment usually takes place via ads that can be shown to users at various places of a webpage. Such ads consist of one or more pictures accompanied by a short study description and a link to an external site hosting the survey (see [26] for an example).

In addition to new platforms for survey research, internet-enabled devices (e.g., mobile phones and activity trackers) can revolutionize current research practice. One example comes from the area of time-use research. The ways in which people use their time (i.e., the quantity and quality of time; whether they spend it alone or interacting with other people or with machines) has implications for their health and wellbeing. Information about people's time use and wellbeing has mainly been collected using (1) recall or (2) real-time techniques. In recall techniques, interviews are typically conducted over the phone or via paper-and-pencil self-administered diaries, where respondents report back about what they did during that day or the previous day, the duration of each activity, where they were, and who they interacted with. This method affords coverage and detail of what participants did during the previous day and the sequence in which activities took place, but it is not very precise in estimating the hour and the minute in which an activity took place [25]. Furthermore, such recall diaries can be lengthy and burdensome for the respondent, which is why most national representative recall-diary surveys are cross-sectional and only cover one or two diary-days for each respondent. 'Real-time' techniques that rely on applications or instant messages received on personal mobile phone have the potential to capture what people are doing 'right now', and are likely to provide a more precise picture of the exact activity [11, 28]. Such techniques also have the advantage of being faster and less fatiguing for the respondent, allowing longitudinal or repeated measures. Additionally, data collection via cellphone applications could provide much needed insight into what people from various socioeconomic contexts and political regimes do during day-to-day life and how those activities are then linked to various measures of wellbeing. Nevertheless, assessing time-use and subjective wellbeing in real time has its own reliability and validity challenges, stemming particularly from the fact that asking respondents to evaluate their current behavior and/or emotional wellbeing 'right now', may change the very behavior and/or emotions we are trying to measure [23, 31].

2 What's next for Demography?

This paper highlighted new opportunities for demographic research created by the Data Revolution. The review of new data sources, however, is not exhaustive and researchers will continue to find new ways of making sense of our social world with the help of the internet and electronic devices. This concluding section considers the unique technical and ethical challenges of digital data and discusses how addressing them can contribute to the advancement of the demographic discipline.

Demographers using digital data face particular issues related to access, representativity, and ethics. Researchers often 'depend on the kindness of strangers' for accessing data since internet companies, unlike governments, are not obliged to share data from their platforms. This creates uncertainty as the conditions of access may change in the future. There are important attempts to address this issue. The Opal Project, for example, has proposed protocols for private companies to willingly share anonymized data on a regular basis to inform public policy and academic research.[5] Furthermore, digital sources are rarely representative of larger populations in the way that randomized surveys are (even if, as this paper has shown, digital technology can enhance the collection of primary survey data). Coverage can also be an issue, as access to the internet is more restricted in LMIC. Nevertheless, digital trace data can be used to show some of these global inequalities in access to digital technologies [15, 17].[6] The issue has motivated research on generalizing from non-representative samples to larger populations [36, 37]. This is a promising area of methodological development with wide applications, especially as survey response rates continue to decline around the world. The availability of online data has also led researchers to think long and hard about data security, privacy and informed consent in the digital era [30]. Ethical considerations must be a primary concern when designing demographic studies using digital or internet data. Social scientists need to adhere to ethical and transparent research practices, particularly as the privacy of users is constantly threatened in the online world [38].

Finally, it is important to note that while innovative sources of data provide exciting opportunities for new research, they are unlikely to make 'traditional' demographic sources obsolete in the near future (e.g., surveys, censuses). Rather, the Data Revolution has the potential to complement and augment these existing data sources. Traditional population data, for example, are crucial for identifying systematic bias in online sources and calibrating estimates made from these data [37]. Social media data can be used to estimate important demographic measures in contexts where traditional survey data are not available. The Data Revolution has already changed the way we do demography, as evidenced by the digitization of historical censuses and populations registers, and the creation of large-scale and open-access repositories of demographic data. The pace of this changes is likely to increase in the future as more researchers engage in ground-breaking research using digital data sources.

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[5] www.opalproject.org/, accessed 28.02.2019.

[6] This work has resulted in efforts to 'nowcast' the digital gender gap in internet and mobile access using real-time big data: https://www.digitalgendergaps.org/, accessed 28.02.2019.

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