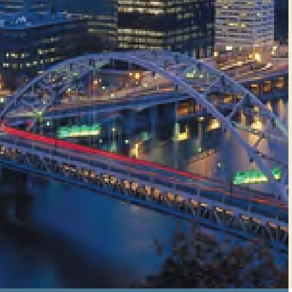

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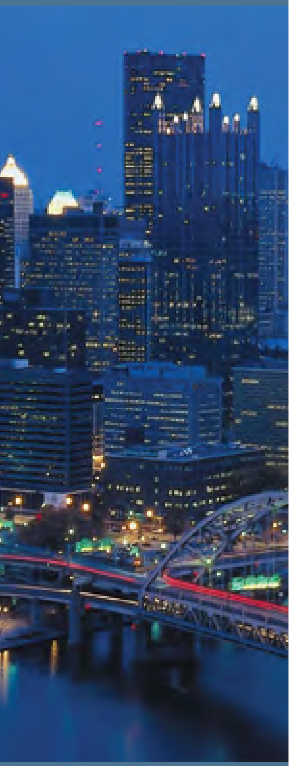

Implementation of Tracking Technologies for Social Science Research

By Noam Shoval

In the last decade or so, we have witnessed unprecedented advances in the collection and use of high-resolution geographic data of moving humans or objects by researchers and the wider public. This is a result of various technological developments, including the continuous development of remote sensing; the creation of free online maps and satellite images of Earth (e.g., Google Maps and Google Earth); and the wide availability of various tracking technologies, such as GPS, Bluetooth, and Wi-Fi.

Most recently, the development and widespread use of smartphones that incorporate tracking abilities in one device that can transfer obtained locations easily and cheaply have been creating important opportunities for research. In parallel, there is a growing ability to analyze the huge space-time databases created by those tracking technologies due to, in particular, the continuous development of geographical information science/systems and, more generally, to the advancements in our computing abilities.

The ability to collect and analyze high-resolution space-time data that cover long periods of time opens up enormous possibilities for initiating new lines of social science

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Impact of Migration on the Pittsburgh Workforce

By Christopher Briem

Population migration plays a major role in regional growth and change across Southwestern Pennsylvania. Even if the rate of net migration is low, larger flows of both in-migration and out-migration continue each year. Population migration has a focused impact on the regional workforce. A significant part of migration within the United States is considered economic migration, driven in large part by workers and their families relocating for employment-related reasons.

Migration rates vary significantly for different parts of the population. In particular, migration rates are much higher for the younger working-age population than for older working-age cohorts. Migration also varies significantly across industries and occupations based on differential rates of employment growth and other factors.

Here, the impact of recent migration flows into the Pittsburgh region is examined. We quantify the number of recent migrants moving into the Pittsburgh region—those arriving in the past year, regardless of origin—and also the number of foreign-born workers in the Pittsburgh region, regardless of the year of their move to Pittsburgh.

Data from the U.S. Census Bureau's American Community Survey (ACS) Public Use Microdata Sample is compiled here to examine metropolitan migration trends. Data from the ACS five-year (2008–12) data set are compiled for the Pittsburgh metropolitan statistical area (MSA), currently defined as a seven-county area comprising Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland counties in Southwestern Pennsylvania.

ACS is an ongoing survey that includes a question asking respondents where they lived one year earlier. ACS compiled data can be used to estimate the size of

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the population that has recently moved into the Pittsburgh MSA. The migration flows compiled here should be interpreted as an annual average over the five-year period data were collected. Here, a migrant is defined as someone who has moved into the Pittsburgh region from elsewhere, either within the United States or from abroad. Also compiled here are data on the number of foreign-born workers within the Pittsburgh workforce. The foreign-born population includes both recent migrants and those who arrived in the United States years or even decades ago.

This analysis focuses specifically on workers currently employed in the Pittsburgh MSA, with the migration data broken down by occupation. The current Standard Occupational Classification system used by the Census Bureau classifies workers into one of 840 detailed occupations, which are grouped into 23 major occupation groups. The migration analysis here reports the breakdown of recent migration across 22 major occupation groups, with military occupations excluded.

Across the 2008–12 period, 33,882 employed residents in the Pittsburgh area, or 3 percent of the employed workforce in the Pittsburgh MSA, resided outside the region one year earlier (see Table 1).

Across occupations, there are many differences in the proportion of workers who have recently migrated to the Pittsburgh region. Life, physical, and social science occupations were the most influenced by recent migration into the Pittsburgh MSA, with 7.1 percent of employed workers living outside the region one year earlier, followed by computer and mathematical occupations (6.8 percent). The largest number of workers who recently moved into the region are employed in the office and administrative support occupation group, which also is the largest occupation group among all workers in the Pittsburgh region.

Separate estimates were calculated for the number of foreign-born workers in the Pittsburgh region. An estimated 47,783 workers, or 4.2 percent of the employed workforce in the Pittsburgh MSA, are estimated to have been born outside the United States, regardless of year of entry.

Similar to the overall flow of migrants into the Pittsburgh region, foreign-born workers also make up the largest proportion of life, physical, and social science occupations, with more than 16.1 percent of workers in the Pittsburgh region born overseas, again closely followed by computer and mathematical occupations (15.3 percent).

Unlike the overall pattern for recent migrants, the largest number of foreign-born workers in the Pittsburgh MSA are employed in management occupations, closely followed by education, training, and library occupations, and also by health

Table 1. Migration Status by Occupation Group

Employed Civilian Population 16 Years of Age and Over, Pittsburgh MSA, 2008–12
Ranked by Percentage Living Outside the Pittsburgh MSA One Year Prior

Occupation Group	Total	Lived Outside the Pittsburgh MSA One Year Earlier	
Life, Physical, and Social Sciences	11,326	799	7.1%
Computer and Mathematical	29,295	1,988	6.8%
Architecture and Engineering	22,638	1,112	4.9%
Food Preparation and Serving Related	67,649	2,763	4.1%
Personal Care and Service	38,141	1,549	4.1%
Education, Training, and Library	63,089	2,306	3.7%
Healthcare Practitioners and Technical	80,770	2,829	3.5%
Arts, Design, Entertainment, Sports, and Media	17,385	608	3.5%
Business and Financial Operations	54,993	1,894	3.4%
Farming, Fishing, and Forestry	1,986	64	3.2%
Management	103,921	3,187	3.1%
MSA Total	**1,124,655**	**33,879**	**3.0%**
Community and Social Service	23,475	699	3.0%
Sales and Related	122,265	3,488	2.9%
Protective Service	20,254	537	2.7%
Office and Administrative Support	163,941	3,940	2.4%
Legal	12,811	283	2.2%
Production	61,154	1,342	2.2%
Construction and Extraction	52,187	1,091	2.1%
Building and Grounds Cleaning and Maintenance	39,444	809	2.1%
Transportation and Material Moving	69,227	1,402	2.0%
Health Care Support	33,395	588	1.8%
Installation, Maintenance, and Repair	35,309	601	1.7%

care practitioners and technical occupations (see Table 2).

Ongoing migration trends will continue to impact the workforce of the Pittsburgh region into the future, as is common across the nation. Employment-related reasons are the primary cause of population migration among the working-age population within the United States. Greater levels of workforce migration reflect the broad national competition for workers in many industries, especially in growth industries. Outreach efforts must succeed to attract and retain workers in these competitive areas.

Table 2. Foreign-born Workers by Occupation Group

Employed Civilian Population 16 Years of Age and Over, Pittsburgh MSA, 2008–12
Ranked by Percentage Foreign-born

Detailed Occupation Group	Total	Foreign Born	
Life, Physical, and Social Science	11,326	1,819	16.1%
Computer and Mathematical	29,295	4,478	15.3%
Architecture and Engineering	22,638	2,034	9.0%
Education, Training, and Library	63,089	4,839	7.7%
Health Care Practitioners and Technical	80,770	4,715	5.8%
Management	103,921	5,168	5.0%
Farming, Fishing, and Forestry	1,986	98	4.9%
Arts, Design, Entertainment, Sports, and Media	17,385	847	4.9%
Personal Care and Service	38,141	1,702	4.5%
Food Preparation and Serving Related	67,649	2,948	4.4%
Building and Grounds Cleaning and Maintenance	39,444	1,687	4.3%
MSA Total	**1,124,656**	**47,783**	**4.2%**
Business and Financial Operations	54,993	2,273	4.1%
Legal	12,811	448	3.5%
Production	61,154	1,823	3.0%
Transportation and Material Moving	69,227	2,011	2.9%
Sales and Related	122,265	3,287	2.7%
Office and Administrative Support	163,941	4,328	2.6%
Community and Social Service	23,475	613	2.6%
Construction and Extraction	52,187	1,241	2.4%
Health Care Support	33,395	703	2.1%
Protective Service	20,254	266	1.3%
Installation, Maintenance, and Repair	35,309	455	1.3%

Implementation of Tracking Technologies for Social Science Research

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inquiry and formulating new research questions that could not be answered previously.

The Rise of GPS and Other Tracking Technologies as Research Tools

Until recently, the most common method for gathering information on human time-space patterns was the time-space diary. This method provides a systematic record of the way in which individuals occupy their time in space over a limited period, such as a few hours, a day, or a week.

While time-space diaries have been used to great effect, they have several disadvantages. In particular, they require that the subjects are actively involved in the process of data collection by recording, in detail and at length, their activities throughout the entire experiment. Because participants often fail to record their actions faithfully, the data obtained are often of questionable credibility.

In recent years, the rapid development and availability of small, cheap, and reliable tracking devices have led to a remarkable increase in research on human space-time behavior. Global Positioning System (GPS) devices offer researchers the opportunity of continuous and intensive high-resolution data collection in time (seconds) and space (meters) for long periods of time. This has never been possible before in social science research. GPS and other tracking technologies now are used in a wide variety of fields, such as environmental, tourism, transportation, and various areas of medicine.

The Emergence of the Smartphone

In 1999, the Japanese firm NTT DOCOMO, Inc., took advantage of its then new i-mode mobile Internet service to successfully release advanced mobile phones with Internet connectivity. This was the first time in which smartphones were adopted massively within a country, and by 2001, NTT DOCOMO had about 40 million subscribers. Outside Japan, smartphones started to appear in the market in the mid-2000s, but the launch of the first-generation iPhone in June 2007 and, a year later, the wide adoption of the Android operating system opened a new phase in the history of mobile phones and mobile computing. In February 2012, more than 50 percent of the phones in the United States were smartphones, and today, the numbers are significantly higher and not only in the most developed countries.

Smartphones can be defined as highly programmable ubiquitous mobile phone devices that integrate powerful computing abilities, advanced communication components, and various embedded sensors that include geolocation technologies. While smartphones were not originally designed as academic research tools, their capabilities make them useful for human behavior research in general and for geographical and mobility studies more specifically. Smartphones incorporate a set of embedded sensors that can be programmed to gather information about the activity of users and their surroundings. These sensors include various location technologies (GPS, cell tower identification, Wi-Fi positioning), proximity technologies, accelerometer, gyroscope, magnetometer (compass), light sensor, microphone, and camera. In addition, sensors such as barometer, ambient thermometer, humidity sensor, and pedometer that are available in some higher-end smartphones today might become the gold standard of smartphones in the near future, allowing for even more sophisticated sensing abilities.

Three main research efforts evolved coincidentally with smartphone development. The first, and probably the least explored, includes the analysis of large data sets that are generated by smartphones independently of any research project. Online social networks such as Twitter, Flickr, and Foursquare that usually include location-based capabilities are a major data source for these investigations. Most of the studies in this category explore mass behavior patterns of large populations. The second type of studies that we recognize includes pioneering or proof-of-concept studies that demonstrate the feasibility of using smartphones to collect information about human behavior. In some of these studies, the focus of the researchers is on the usage and analysis of the data that were generated by smartphones rather than on the data collection procedure itself.

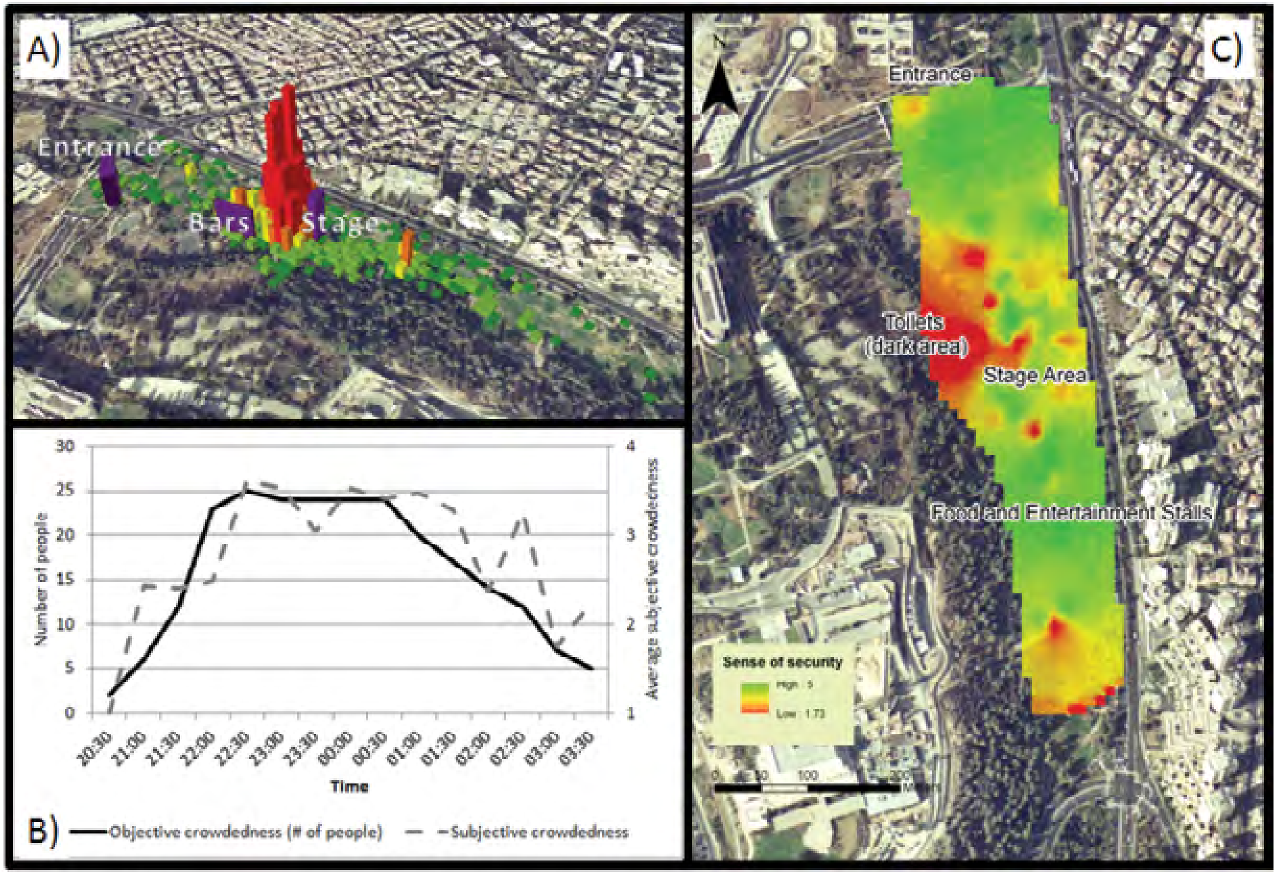
Finally, computer science researchers have published several works that describe the development and implementation of new mobile applications and systems that take advantage of smartphone capabilities and especially their sensors. In these works, researchers usually implement their applications on small pilot studies in order to test their systems.

Example: The Hebrew University of Jerusalem Student's Day

While the ability to collect real-time contextual information about participants with stand-alone tracking devices is relatively limited, in contrast, smartphones allow us to gather contextual information beyond the where and when in a more straightforward way. This may include subjective reports of behavior as well as more objective variables about the social and physical environment. Here, we describe a pilot study at the Hebrew University of Jerusalem's Student's Day.

The authors developed this smartphone application to monitor crowdedness levels during a mass event. This example demonstrates how mobile sensing may enrich our data with contextual information, in this case

Figure 1.



with data about subjective perceptions of people about their environment.

The event took place in Sacher Park, the largest urban park in the center of Jerusalem, where the annual Student's Day celebrations took place in 2013. Twenty-five students uploaded the application to their smartphone devices and were asked to report about their subjective sense of crowdedness and security. The location of the students also was monitored based on the various location sensors of the phone. Students received a 50 NIS incentive (~14 USD) for their participation.

We divided the park area into 10 m by 10 m cells (see Figure 1A) and aggregated the amount of time that the students spent in each cell as recorded passively by the mobile application. The total time of stay was represented by both the colors and the height of the cells.

High concentration of people in front of the stage area are visible where the students observed the performances. The area behind the stage included food stands and other merchandise stalls, where people were attracted for shorter periods of time.

The black curve in Figure 1B shows the distribution of the number of students in the festival compound in intervals of 30 minutes. We can see that all 25 students were present in the park at 22:30 and that the students gradually started to leave the park soon after midnight.

Participants also were asked to report about their subjective sense of crowdedness and sense of security during the festival by rating it on a scale that ranged from one to five. The reports were automatically geo-tagged by the smartphone application.

The dashed curve in Figure 1B represents the temporal distribution of this subjective sense of crowdedness. We can see that the objective number of people and subjective crowdedness levels have a very similar pattern curve. In fact, the correlation between the two series was found to be very high ($r=0.815$, $\alpha<0.05$). Figure 1C represents the interpolated geo-tagged reports of students about their subjective sense of security. The interpolation reveals that students felt less secure in the toilet area, which was poorly illuminated.

Conclusion and Key Questions for Future Research

The development of GPS receivers, mobile phones, and recently smartphones is a very dynamic domain. In addition, these devices have recently become easily accessible and more affordable to the wider public.

Providing extremely accurate data in time and space, these technologies are

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opening up new and previously infeasible lines of inquiry. All in all, an important point to be clarified is that these technologies do not replace questionnaires, diaries, or interviews, all of which will remain important sources of information on individual activities and the motives underlying these activities. Instead, the new technologies complement, add to, and enrich the findings of these more traditional research tools.

The ubiquity of spatial referencing in our everyday lives in the digital age through geotags, location-based services, check-ins, and tweeting, for example, presents boundless opportunities for geographical research and new approaches besides the mix of traditional methods and mapping practices.

However, these opportunities also raise new questions of geo-privacy intrusion and violation of data confidentiality as well as human subject protection when location or GPS data are collected or used without being regulated by strict protective procedures (e.g., the use of unprotected social media data). They have significant implications for research practice and methodology in geography and beyond.

One open question that is relevant to all types of tracking studies is do people, once they know they are being followed, change their activity and, if so, how? This question should be explored further.

However, even the more traditional methods for gathering information raise concerns as to whether reports are inaccurate (in questionnaires and time budgets) and whether people change their patterns of activity due to participation in a study, feeling that they must behave in a certain way.

The advantage of smartphones is that people are used to carrying their phones on a daily basis regardless of the research intervention. An additional direction of inquiry that has yet to be explored is the integration of tracking data with additional digital sources of data. One of the interesting opportunities in this regard is the employment of external sensors that are compatible with smartphones.

These sensors include biometric sensors that measure excitement and physical effort as well as sensors that measure characteristics of the environment such as noise and pollution levels. External sensors, such as heart rate sensors, already have been implemented in the past successfully.

Another remaining question relates to the large amount of data that is accumulated when using these methods, which requires the development of more algorithms to enable automatic scripts in order to analyze the data in a fast and practical way. It would be beneficial if the software being developed today by different research teams and private companies around the globe on an ad hoc basis could be standardized at some point so that common measures for data analysis could be developed. More importantly, this could lead to an increase in the number of researchers in the field, because the current challenge of analyzing the data no doubt limits the number

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Mildred E. Warner, PhD, Professor, Department of City and Regional Planning, Cornell University, Ithaca, N.Y.

Shrinking Cities: Are We Siting Affordable Housing in Neighborhoods of Opportunity?
Friday, March 20, 2015
Robert Silverman, PhD, Professor and PhD program director, Department of Urban and Regional Planning, University at Buffalo, the State University of New York, Buffalo, N.Y.

Southwestern Pennsylvania Community Profiles

By Sabina Deitrick and Robert Gradeck

The University Center for Social and Urban Research (UCSUR) is completing its new digital tool, Southwestern Pennsylvania Community Profiles, to be available to users in early 2015. Southwestern Pennsylvania Community Profiles (SWPA Community Profiles) welcomes a new way to collect, analyze, and understand information across a range of domains to look at our neighborhoods and communities in a comprehensive data fashion.

SWPA Community Profiles will present community data and indicators in a series of interactive tables, maps, graphs, and charts. With data and indicators from local, state, and federal government sources, along with a select set of other databases, SWPA Community Profiles will allow users to understand and visualize data along a range of geographic areas in our communities and region.

Data are organized along 11 data domains: arts and culture, demographics, economy, education, environment, governance and civic vitality, health, housing and properties, human services, public safety, and transportation. Within each domain is information important to understanding the changes, trends, and developments that are affecting our local areas.

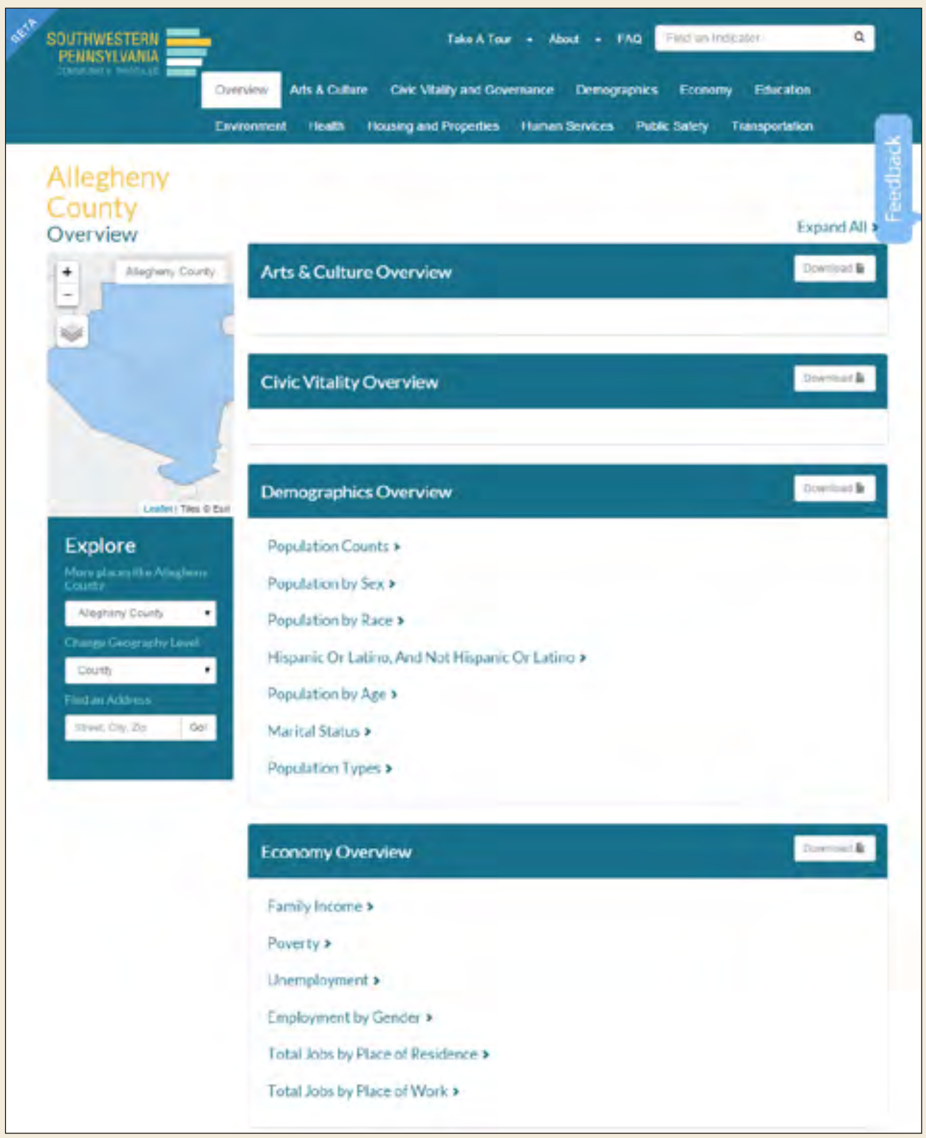
Data are available by different geographies, from county and municipal levels down to neighborhood and census tract and block groupings. Not all information is available along all geographies, but much is. Users will click on one of the domains to view a range of data indicators, with options to produce a map to visualize the selected information and compare across different places.

SWPA Community Profiles has been supported by the Allegheny County Department of Human Services (DHS) through its Human Services Integration Fund. Included in the project are DHS data totals by service type and geographic area. This information will be useful for many working in human services fields in understanding complex relations through an integrated data system and conducting comprehensive assessments with these data tools.

SWPA Community Profiles was developed with the Providence Plan and software pioneered through it's Rhode Island Community Profiles project. UCSUR and the Providence Plan are partners in the National Neighborhood Indicators Partnership (NNIP), based at the Urban Institute in Washington, D.C.

UCSUR has long been a part of the "democratizing data" movement, a focus on making information public and easily accessible to users. SWPA Community Profiles will be central to those efforts in our region. Residents, nonprofit organizations, businesses, governments, and others will find information invaluable for a wide range of uses and be able to use information and data in their efforts to build community capacity and improve quality of life.

UCSUR will be conducting training and information sessions for the SWPA Community Profiles site over the coming months. If you are interested, please contact us at: pncis@pitt.edu.



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