Procedures for Estimating in the Uniform Crime Reporting (UCR) Program

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The UCR Program will begin offense estimation in the 2013 *Crime in the United States* (*CIUS*) publication. The following information details the intended method for achieving a valid and reliable estimate and uses an example of Arson offense estimation to demonstrate the employed statistical model.

Currently, the UCR Program publishes Arson offense data by agency population group, shown in Arson Table 1, and by individual law enforcement agency (*CIUS* Tables 8-12, not shown). Offense totals are represented as a rate per 100,000 persons. Based on aggregated population group rates in Arson Table 1 and individual agency data, the UCR Program is capable of reporting agency imputations and national estimations for arson offenses in its publications.

Arson Table 1[1]

Arson Rate

by Population Group, 2011
[13,045 agencies; 2011 estimated population

263,872,098; rate per 100,000 inhabitants]

Population group	Rate
TOTAL ALL AGENCIES	**18.2**
TOTAL CITIES	20.7
Group I (250,000 and over)	32.8
1,000,000 and over (Group I subset)	28.2
500,000 to 999,999 (Group I subset)	31.8
250,000 to 499,999 (Group I subset)	38.6
Group II (100,000 to 249,999)	20.7
Group III (50,000 to 99,999)	16.9
Group IV (25,000 to 49,999)	14.9
Group V (10,000 to 24,999)	13.3
Group VI (under 10,000)	20.3
Metropolitan counties	13.2
Nonmetropolitan counties	12.2
Suburban areas[2]	12.8

[1] US Federal Bureau of Investigation (2012). *Arson Table 1*. Retrieved from http://www.fbi.gov/about us/cjis/ucr/crime-in-the-u.s/2011/crime-in-the-u.s.-2011/tables/arson-table-1

[2] Suburban areas include law enforcement agencies in cities with less than 50,000 inhabitants and county law enforcement agencies that are within a Metropolitan Statistical Area. Suburban areas exclude all metropolitan agencies associated with a principal city. The agencies associated with suburban areas also appear in other groups within this table.

National Estimation

National estimates for offense data will be computed by using the "Total All Agencies" rate per 100,000 persons and multiplying it to the national population estimate provided by the US Census. This is done with the following formula:

$$\frac{US\,Population * National\,Rat\,e}{100{,}000} \cong National\,Offense\,Estimation$$

For example, using the rate for arson offenses from the 2011 Arson Table 1 and the 2011 US Census population estimates, a national number of estimated arson offenses can be derived.

As shown in Arson Table 1, the national rate for arson is reported as 18.2 offenses per 100,000 persons. The US Census reports the estimated US population for 2011 was 311,591,917 persons[3]. By multiplying the US population estimate to the rate of arson offenses per 100,000 persons, an estimated number of arsons may be computed. In this manner, approximately 56,710 arson offenses occurred in the US in the 2011:

$$\frac{311{,}591{,}917 * 18.2}{100{,}000} \cong 56{,}710$$

According to the 2011 CIUS, 52,333 arson offenses were reported by 15,640 law enforcement agencies providing 1-12 months[4].

As with any estimation, a range should be used to bound the estimate as a sample can never estimate a population with pinpoint accuracy. Rather the sample estimation should provide a range within which the true population of arson offenses exists. The arson estimation range is computed by adding and subtracting bound for population estimation, as illustrated in the following formula[5]:

$$\pm 2\sqrt{N^2\left(\frac{s^2}{n}\right)\left(\frac{N-n}{N}\right)}$$

Where,

s^2 = the standard deviation of arson offenses reported by 12-month complete agencies,
n = the number of agencies reporting 12-months of arson data (effectively a sample of agencies), and
N = the number of agencies in the UCR Program.

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[3] US Census Bureau. (2012). *Population Estimates: Vintage 2011.* Retrieved from http://www.census.gov/popest/data/state/totals/2011/tables/NST-EST2011-01.xls

[4] US Federal Bureau of Investigation. (2012). *Arson*. Retrieved from http://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2011/crime-in-the-u.s.-2011/property-crime/arson

[5] Scheaffer, R. L., Mendenhall III, W., Lyman, O. (1996). *Elementary Survey Sampling*, 5th ed. Duxbury Press: Washington D.C., p. 92.

Using the prior example, the standard deviation for the sample individual agencies reporting 12-months complete data in 2011 was 22.3[6]. Including non-reporting agencies, the number of total agencies in the US was 18,233. Based on this information, the bound is computed as:

$$\pm 2\sqrt{\left(18{,}233^2\left(\frac{22.3}{9{,}228}\right)\left(\frac{18{,}233-9{,}228}{18{,}233}\right)\right)} \cong 1{,}260$$

Thus, the estimated number of arson offenses for 2011 is 56,710 and the true population of arson offenses in the United States is expected to be between 55,450 and 57,970:

$$56{,}710 \pm 1{,}260 = (55{,}450\,;57{,}970)$$

Crime data is reported by month, and some agencies, even large ones, do not always report all 12 months of data within the reporting year. Monthly estimates can be computed and summed at the end of the year in order to derive a more accurate estimate which encompasses all agencies in the sample population. In such cases the formulas for computing the national crime estimate and bound change to the following formulae:

Estimation

$$\frac{US\,Population * Monthly\,National\,Rate}{100{,}000} \cong Monthly\ National Offense\ Estimation$$

Bound

$$\pm 2\sqrt{\left(N^2\left(\frac{s^2}{n}\right)\left(\frac{N-n}{N}\right)\right)_{jan} + \left(N^2\left(\frac{s^2}{n}\right)\left(\frac{N-n}{N}\right)\right)_{feb} + \ldots + \left(N^2\left(\frac{s^2}{n}\right)\left(\frac{N-n}{N}\right)\right)_{dec}}$$

Where,

s^2 = the standard deviation of arson offenses reported for the corresponding month,
n = the number of agencies reporting arson data (effectively a sample of agencies) within the month, and
N = the total number of agencies in the UCR Program per month.

In this manner the FBI UCR Program will begin to publish estimates for national level crime estimations.

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[6] Based on an analysis of 12-month arson reporting agencies in Table 8 of the 2011 *CIUS*. US Federal Bureau of Investigation. (2012). *Table 8: Offenses Known to Law Enforcement.* Retrieved from http://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2011/crime-in-the-u.s.-2011/tables/table_8_offenses_known_to_law_enforcement_by_state_by_city_2011.xls

One of the weaknesses of this method is the sample of agencies reporting data is based on a convenience sample as participation in the UCR Program is voluntary. Although the UCR Program attempts to engage its contributors and encourage participation, crime data reporting from law enforcement agencies is ultimately based on each agency's willingness and ability to submit crime data. The resulting sample of agencies is therefore not scientifically selected and it is assumed the sample is representative of the population of agencies in the US.

A benefit of this method is it can also be used to impute arson data for agencies not reporting 12-months of data. By multiplying an agency's estimated population to the crime rate based on the agency's population group, and applying the estimation bound described previously, individual agency offense estimations and ranges can be computed and used in trends or other statistical analyses.

This method also has other uses within the UCR Program, including providing estimations for other reported data collections, including Part I crimes, police employment data, arrest data, hate crime, cargo theft, human trafficking, and the Law Enforcement Officer Killed and Assaulted program. Specific methodological considerations need to be addressed for unique data concerns within each data collection, but a method similar to the arson estimation example can be used as the base estimation model for those programs.