

# MORTALITY DATA FOR THE UNITED STATES MORTALITY DATABASE (USMDB)<sup>1</sup>

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## **GENERAL**

National censuses and population estimates for the United States are produced by the U.S. Department of Commerce at the US Census Bureau ([www.census.gov](http://www.census.gov)). Vital statistics data are collected and disseminated by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control (CDC) ([www.cdc.gov/nchs/](http://www.cdc.gov/nchs/)). Though information on burials was collected routinely in some areas of the United States in the 19<sup>th</sup> century, it is only in 1933 that the quality of the information collected was deemed good enough (with over 90% of vital events registered) in all of the States and the District of Columbia for the system to cover the whole territory of the United States (National Research Council, 2009). The present format of US death certificates was established in the 1940s and follows the recommended international standards. It has been revised periodically to reflect medical progress and changing public health concerns (Rosenberg, 1999). The last notable revision was implemented in 2003.

## ***Sources of Data***

The USMDB population data originate from population censuses conducted every 10 years. The USMDB makes use of the censuses conducted from 1960 to 2010. Census counts serve as the basis for producing annual July 1<sup>st</sup> population estimates for intercensal and postcensal periods, published by the Census Bureau. Postcensal population estimates are revised every year and intercensal population estimates are substituted to postcensal estimates as new census data become available. Intercensal population estimates are available at the state level for all years since 1970. They have been published on the Census Bureau website (U.S. Census Bureau, Population Estimates Program, <https://www.census.gov/programs-surveys/popest.html>). Additional (sometimes more detailed) census data are available through the Inter-University Consortium for Political and Social Science Research (ICPSR, [www.icpsr.umich.edu](http://www.icpsr.umich.edu)) with restricted access for participating organizations. For years between 1959 and 1969, we constructed our own annual intercensal population estimates using census data and birth and death counts by age during the intercensal period. To construct these estimates, we followed strictly the methods of the Human Mortality Database Version 5 (Wilmoth et al., 2007).

Starting with 1959, data on deaths are available electronically from the National Center for Health Statistics (NCHS) in the form of Mortality Multiple Cause of Death

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<sup>1</sup> This document partly relies on the information included in the Human Mortality Database Background and Documentation File for the United States (<http://www.mortality.org/hmd/USA/InputDB/USAcom.pdf>), initially prepared by Ludmila Andreeva.

Files (see National Center for Health Statistics, 1959–). These data include individual death records coded from death certificates. Public files are available on the NCHS website, at [https://www.cdc.gov/nchs/data\\_access/vitalstatsonline.htm](https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm). However, geographic information (including state of residence and state of occurrence) has been suppressed from the public files for years since 2004 to protect confidentiality. Access to the restricted data is only possible through special arrangement. The USMDB has obtained access to these data through the Berkeley Research Data Center after completing a strict vetting procedure. All of the USMDB mortality data processing has taken place within the RDC (including for years prior to 2004 because more detailed information on the date of birth is available in the restricted files, which allow for a more accurate allocation of deaths to the upper or lower Lexis triangle for each combination of age and year of death).

## **TERRITORIAL COVERAGE**

Since 1959, when both Alaska and Hawaii became US states, national statistics has been publishing information for all 50 states and the District of Columbia. There has been no change to state boundaries since then.

## **DEATH COUNT DATA**

### ***Coverage and Completeness***

In the early years of the 20<sup>th</sup> century, vital statistics for United States were based on data from those states admitted to the Death Registration Area, the number of which increased over time. To be included in the Death Registration Area, the vital statistics system for a state had to demonstrate coverage of at least 90% of the state population. This process was completed in 1933 for the US as a whole with the admission of Texas into the Death Registration Area. Given the legal requirements for death registration, mortality data for the United States are considered to be complete and of acceptable quality since 1933.

Mortality data for the United States are confined to events registered within the territory of the United States. Vital events to US residents occurring outside of the United States are not included but those to non-US resident occurring within the United States are. Since 1970, it is possible to identify deaths of non-residents and, consequently, to exclude them from tabulations. Therefore, for the years 1959–1969, deaths in the USMDB include both residents and nonresidents (i.e., the *de facto* population), and for the period starting in 1970, only residents are included.

### ***Specific Details***

#### **Deriving Death Counts by Lexis triangles from Individual Death Records**

Death counts for years since 1989 can be precisely tabulated by Lexis triangle (i.e., by age and birth cohort) because the original data from NCHS include the exact date of birth as well as the exact date of death.

For prior years, the original data identify deaths by single year of age, but not by birth cohort (because the date of birth is not included on the death records). It is possible to estimate deaths by Lexis triangle using the exact date of death, although this

approximation (and the resulting mortality estimate) is unlikely to be as accurate as the observed counts for years in which the date of birth is available. Procedures used to derive the death counts by Lexis triangle for years prior to 1989 are described in Appendix 2.

## **POPULATION COUNT DATA**

### ***Coverage and Completeness***

Data on population refer to the resident population of the United States. No adjustments have been made to the published population estimates.

### ***Specific Details***

Because the Census Bureau annual state-level population estimates by sex and age are only available for years since 1970, we have constructed our own intercensal estimates using a cohort component method described in the 2007 Human Mortality Database Methods Protocol (<http://v5.mortality.org/Public/Docs/MethodsProtocol.pdf>) for the years 1959-1969. Further details are provided in Appendix 3.

## **BIRTH COUNT DATA**

### ***Coverage and Completeness***

As for the mortality statistics, due to the legal requirements of birth registration, data on births are considered to be virtually complete and of a good quality since 1933.

Birth data for the United States are confined to events registered in the United States. Births to legal residents of the U.S. that occurred in other parts of the world are excluded from published vital statistics. Prior to 1970, births to non-residents (that occurred in the US) were included in the statistics, whereas for 1970 and thereafter, births to non-residents are excluded.

### ***Specific Details***

The distribution of births by sex at the state level was missing from the NCHS files for the year 1967. In the USMDB, we thus used the state-specific average of the sex ratio in the two surrounding years, i.e. 1966 and 1968, to split the births by sex within each state.

## **ACKNOWLEDGEMENTS**

We are grateful to Elizabeth Arias and Robert Anderson at NCHS for their collaboration to this project. We also wish to acknowledge John Wilmoth, current Director of the Population Division at the United Nations, and former PI for this project, who developed the initial idea for the USMD. We also recognize the contributions of Kirill Andreev and of Ludmila Andreeva to the early stages of the USMDB. And of course, this project would not have been possible without prior experience with the Human Mortality Database (HMD), including all the work carried out by both the DataLab team at the Max Planck Institute for Demographic Research and in the Department of Demography

at the University of California, Berkeley, to develop the HMD Methods Protocol, of which we have made extensive use in the USMDB.

Financial and logistical support was received from the USMDB two sponsoring institutions, the Department of Demography at the University of California, Berkeley (UCB) and the NIA-funded Center on the Economics and Demography of Aging at UCB (CEDA). The project has been initially funded by a grant (R01 AG040245) awarded to John Wilmoth by the National Institute on Aging (NIA). Additional technical and research support has been provided by the French Institute for Demographic Studies (INED). Additional financial support has been provided to the project on an annual basis since 2016 by the Society of Actuaries-REX Pool Fund as well as through occasional gifts from the following sponsors: the AXA Research Fund, SCOR, Hannover-Re and Reinsurance Group of America (RGA). None of the funders had any role in the data collection, analysis, preparation, review or approval of the final data series.

## **REFERENCES**

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## APPENDIX 1: DESCRIPTION OF USMDB INPUT DATA<sup>2</sup>

### DEATHS

Period	Type of Data	Age groups	Comments	RefCode(s)
1959-2016	Annual death counts for U.S. residents by geographic area, sex, single year of age and date of death (in months)	0, 1,...maximum age attained	Deaths to U.S. residents occurring in outlying territories (e.g., Puerto Rico, U.S. Virgin Islands) or a foreign country (including Canada) are excluded, as are deaths to non-residents for years since 1970. Deaths have been tabulated from individual records. <sup>†</sup>	1

† For details, see Appendix 2.

<sup>2</sup> The reference codes indicated in the last column of each of the tables below correspond to the sources listed in Appendix 4.

**POPULATION**

Period	Type of Data	Age groups	Comments	RefCode(s)
1960	Official Census estimates	0, 1, ... , 84, 85-89,90-94,95-99,100+	<b>Error! Reference source not found.</b>	10, 11, 12
1970	Official Census estimates	0, 1, ... , 84, 85-89,90-94,95-99,100+		20
1971–1979	Intercensal population estimates for the resident population	0, 1-4, 5-9, ..., 80-84, 85+		40
1980	Official Census estimates	0, 1, ... , 89, 90-94, 95-99,100+		50
1981–1989	Intercensal population estimates for the resident population <sup>†</sup>	0, 1 ... 85+		60
1990	Official Census estimates <sup>‡</sup>	0, 1, ... , 89, 90-94, 95-99,100+		70
1991–1999	Intercensal population estimates for the resident population <sup>†</sup>	0, 1 ... 85+		80
2000	Official Census estimates <sup>‡</sup>	0, 1, ... , 99, 100-104, 105-109, 110+		90
2001–2009	Intercensal population estimates for the resident population <sup>†</sup>	0, 1 ... 85+		100
2010	Official Census estimates <sup>‡</sup>	0, 1, ... , 89, 90-94, 95-99,100+		110
2011-2016	Intercensal population estimates for the resident population <sup>†</sup>	0, 1 ... 85+		120

† For details, see Appendix 3.

‡ Data are available on the Census Bureau web site (<http://www.census.gov>). For the specific URLs and download dates, see the reference file for the raw data.

**BIRTHS**

Period	Type of Data	Comments	RefCode(s) <sup>†</sup>
1959– 1964	Annual births for the <i>de facto</i> population by sex	Counts for 1959 have been adjusted to include births that occurred in Hawaii (see section “Births Count Data”). No sex detail for year 1967 (see the Specific Details in the “Birth count data” section above for imputation method).	200
1965– 1979	Annual births for the <i>de facto</i> population by sex		210
1980– 2003	Annual births for the resident population by sex	Births to U.S. residents that occurred abroad are excluded as are births to non-residents.	220
2003– 2006	Annual births for the resident population by sex	Births to U.S. residents that occurred abroad are excluded as are births to non-residents.	230
2007– 2016	Annual births for the resident population by sex	Births to U.S. residents that occurred abroad are excluded as are births to non-residents.	240

## **Appendix 2:**

### **Tabulation of Deaths from the Mortality Detailed Files by Lexis triangle**

The information required to precisely and accurately allocate each death to either the upper or the lower Lexis triangle within each combination of single year of age and calendar year is the birth cohort. This combination of information is available for all years since 1989 in the restricted mortality files to which we have access but information on the date of birth is not available for years 1959-1988. In some instances, there are inconsistencies between the date of birth, the date of death, and the age at death (Appendix Table 1). In addition, some of the information is missing for a small number of records, though the number and proportion of problematic records (with either inconsistencies or missing information) has always been marginal (representing less than 0.5% of all records in 1989) and has been declining consistently over time (representing less than 0.05% of all records for years since 2013). For those records with inconsistencies between the age at death, the date of birth and the date of death, we decided to ignore age and only rely on the dates of birth and death, *except* for those records when the age at death was below one. This is because in such cases, the information provided is extremely detailed (down to the number of minutes lived) which makes it less likely than a coding error would have occurred.

#### **WHEN THE BIRTH COHORT IS UNKNOWN**

For years of data (1959-1988) when we lack information about the date of birth (and thus about the cohort to which the deceased belonged), we indirectly estimated the Lexis triangle to which deaths should be allocated. As noted earlier, the age variable identifies the age of the decedent at his/her last birthday in single years. The month of death is provided as well as, for several years (1962-1967 and since 1972), the exact date of death. This information was used in the USMDB to allocate the death counts to each Lexis triangle as further explained below.



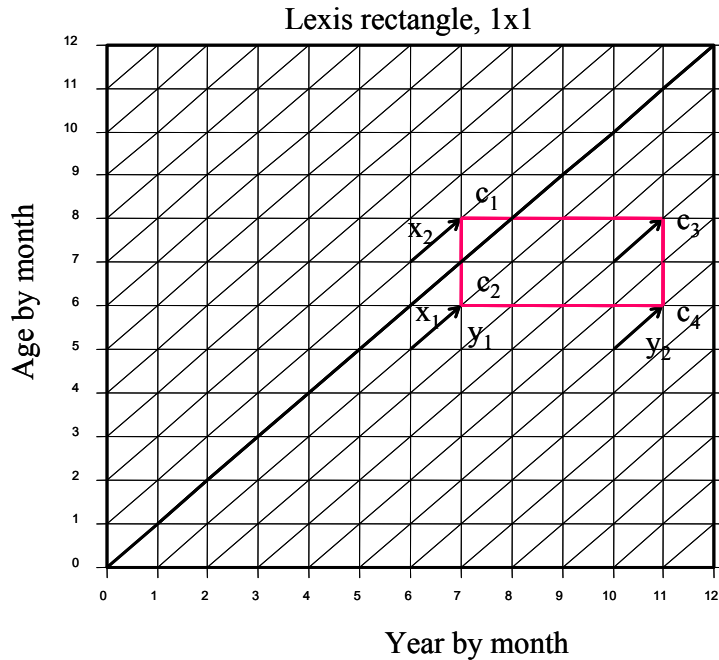
Table 1. Number of death records with inconsistent or missing information, 1989-2016

Year	All dates/age complete and consistent	Inconsistencies between the age and dates of birth/death	Missing age only	Missing date of birth only	Missing age and date of birth	All incomplete or inconsistent records	In proportion to total records
1989	2150466	6472	45	3183	517	10217	0.48
1990	2148463	6023	45	2949	517	9534	0.44
1991	2169518	5920	29	2476	547	8972	0.41
1992	2175613	5120	7	1963	467	7557	0.35
1993	2268553	4891	25	1883	482	7281	0.32
1994	2278994	4181	29	1578	385	6173	0.27
1995	2312132	3520	36	1646	427	5629	0.24
1996	2314690	3584	25	1603	498	5710	0.25
1997	2314245	3355	17	1697	384	5453	0.24
1998	2337256	3275	2	1400	409	5086	0.22
1999	2391399	2980	8	1077	348	4413	0.18
2000	2403351	2108	2	868	354	3332	0.14
2001	2416425	2286	4	955	418	3663	0.15
2002	2443387	2616	2	939	355	3912	0.16
2003	2448288	2380	2	850	340	3572	0.15
2004	2397615	2027	3	614	343	2987	0.12
2005	2448017	2099	8	487	247	2841	0.12
2006	2426264	1779	1	524	219	2523	0.10
2007	2423712	1931	8	326	193	2458	0.10
2008	2471984	1675	0	217	147	2039	0.08
2009	2437163	1167	1	179	254	1601	0.07
2010	2648435	891	1	301	125	1318	0.05
2011	2515458	980	2	144	132	1258	0.05
2012	2543279	1208	0	170	147	1525	0.06
2013	2596993	798	0	137	132	1067	0.04
2014	2626418	661	0	164	163	988	0.04
2015	2712630	414	0	73	138	625	0.02
2016	2744248	345	0	52	137	534	0.02

Figure 1 illustrates a 1x1 Lexis square (by age and year of death), divided into two Lexis triangles (by age, birth cohort, and year), each of which is further divided into 144 smaller Lexis triangles (by age in months, birth month, and month of death). Suppose that we know a death occurred between July and November (months 7-11) and between age ( $x + 6$  months) and ( $x + 8$  months) (shown by the red rectangle in Figure 1). The red rectangle includes 16 of the smaller Lexis triangles (by month), of which 15 belong to the lower Lexis triangle (by year) and one to the upper triangle. If we assume that the probability of dying is the same in each of the smaller Lexis triangles, then the

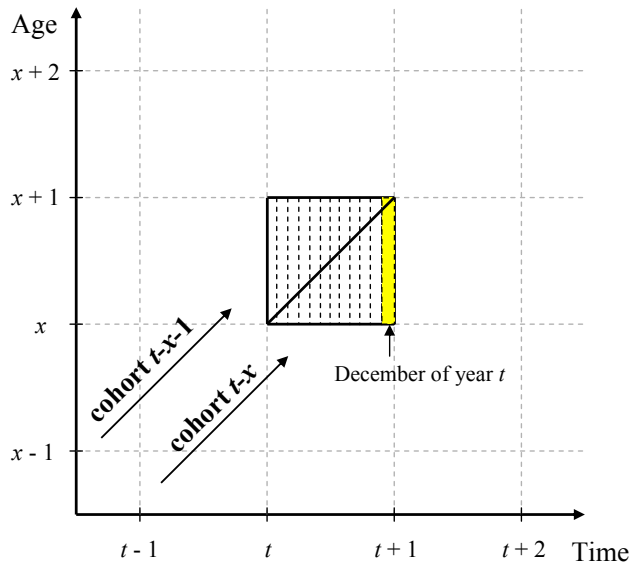
probability that such deaths occurred to someone from the older cohort is  $1/16$ . Therefore, among all individual death records that fall within this red rectangle, we assign  $1/16^{\text{th}}$  of such deaths to the upper triangle and  $15/16^{\text{th}}$  to lower triangle. This simple example captures the gist of the method.

Figure 1. 1x1 Lexis Square by age (in months) and month/year of death



**WHEN ONLY THE MONTH OF DEATH IS AVAILABLE**

For some years (1959–1961 and 1968–1971), only the month and year of death are included in the MDF (not the day of death or the date of birth). Therefore, within a given 1x1 Lexis square (age by calendar year), we can further split the deaths into 12 rectangles representing the month of death (age by month/year of death), as shown on Figure 2. The proportion of deaths falling within the upper and lower triangles of each rectangle can be computed assuming a uniform distribution of deaths. For example, for deaths occurring in December of year  $t$  (shown in yellow on Figure 2),  $23/24^{\text{th}}$  would fall into the lower triangle and  $1/24^{\text{th}}$  in the upper triangle.

**Figure 2. Illustration of Lexis Triangles and Rectangles****EXACT DEATH OF DEATH AVAILABLE**

For some other years (1962-1967 and 1972-1988), the files include complete information for the date of death but the date of birth is not available. Therefore, a procedure similar to that described in the previous section can be applied. That is, deaths within each 1x1 Lexis square can be split into 365 rectangles representing each possible day of death. Again assuming that deaths are distributed uniformly within each of these rectangles, the proportion of deaths falling within the upper and lower triangles can be computed.

**WHEN THE EXACT DATES OF BIRTH AND DEATH ARE AVAILABLE**

For years since 1989, the exact dates of birth and death (day, month and year) are available in the data files. Thus, it is possible to identify precisely whether the death occurred in the upper triangle or whether it occurred in the lower triangle, without making any assumption.

## **APPENDIX 3:**

### **Population estimates for 1959-1969**

One of the guiding principles of this database is to provide mortality estimates with as much age detail as possible. U.S. data on deaths by single year of age are available starting with 1959. To compute death rates by single year of age, they must be combined with population counts by single year of age, i.e., annual population estimates by state. Such data are not available from the U.S. Census Bureau for years before 1960. We thus had to calculate our own inter-censal estimates for 1959 using the classic demographic approach of a cohort component method. The 1959 estimates by back projecting the 1960 population estimates using the death counts by age within each cohort as well as the birth count for 1959.

In addition, for years 1960-1969, we identified two sets of annual population estimates available from the Census Bureau. A first set of estimates was available by single year of age but yielded figures which were inconsistent with both the 1970 Census counts and the Census count and estimates for 1980 and beyond. A second set was available by five-year age group and highly consistent with prior and succeeding years. We thus decided to use this second set of estimates but redistributed the five-age group deaths to each single year of age using the proportional distribution from the first set of estimates.

## **APPENDIX 4:**

### **Detailed sources of the data used for the USMDB and corresponding RefCodes (see Appendix 1)**

#### RefCode 1

National Center for Health Statistics, United States. Mortality Multiple Cause Restricted Use File, Accessed in the Berkeley RDC 10-Feb-2017

Tabulation of deaths by Lexis triangle from individual records by state, single year of age and birth cohort (where available).

#### RefCode 10

Hybrid series of population data for USA states years 1960 by 1 year age, computed from combined series RefCode 11 and RefCode 12. The primary sources used to construct the hybrid series are:

(Census) Population Data for USA states years 1960, by 5 year age (RefCode 11)

(Census) Population Data for USA states, years 1960 (RefCode 12)

#### RefCode 11

Census of Population: 1960 (Volume I)

U.S. Department of Commerce Bureau of the Census (1961)

Characteristics of the Population

General Population Characteristics

Table 94. Single year of Age by color, nativity, and sex, for the state: 1960

(retrieved from <https://www.census.gov/prod/www/decennial.html> on 13-Apr-2015)

#### RefCode 12

Census of Population: 1960

Department of Commerce

Characteristics of the Population

General Population Characteristics, USA Summary

Table 59. Age by color, sex, for the state: 1960

(retrieved from

<https://www.census.gov/prod/www/decennial.html>

on 5-May-2015)

#### RefCode 20

Census of Population on

U.S. Department of Commerce Bureau of the Census (1972)

Characteristics of the Population

General Population Characteristics

Table 19. Single year of Age by Race and Sex: 1970

(retrieved from <https://www.census.gov/prod/www/decennial.html> on 1-Dec-2014)

#### RefCode 40

United States Department of Commerce. Bureau of the Census.

Intercensal Estimates of the Population of Counties by Age, Sex, and Race [United States]: 1970-1980.

Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 1992-02-16. <https://doi.org/10.3886/ICPSR08384.v1>

(Retrieved from <https://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/8384> on 23-Oct-2015)

RefCode 50

Census of Population on

U.S. Department of Commerce Bureau of the Census

Characteristics of the Population

General Population Characteristics

Table 18. Single year of Age by Race, Spanish Origin, Sex: 1980

(retrieved from

<https://www.census.gov/prod/www/decennial.html>

on 20-May-2015)

RefCode 60

U.S. Department of Commerce Bureau of the Census

State Intercensal Datasets: 1980-1990

State Population Estimates and Demographic Components of Change: 1981 to 1989, by Age, Sex, Race, and Hispanic Origin

(retrieved from

<https://www.census.gov/data/datasets/time-series/demo/popest/1980s-state.html>)

RefCode 70

U.S. Department of Commerce Bureau of the Census

Report Number: CP-1 (Volumes 1990 CP-1-2 to 1990 CP-1-52)

1990 Census of Population: Characteristics of the Population

General Population Characteristics

Table 18. Single year of Age by Race, Spanish Origin, Sex: 1990

(retrieved from

<https://www.census.gov/prod/www/decennial.html>

on 20-May-2015)

RefCode 80

*Center for Disease Control and Prevention*

National Center for Health Statistics

National Vital Statistics System

Bridged-race intercensal population estimates for July 1, 1990-July 1, 1999

(retrieved from [https://www.cdc.gov/nchs/nvss/bridged\\_race/data\\_documentation.htm](https://www.cdc.gov/nchs/nvss/bridged_race/data_documentation.htm))

RefCode 90

U.S. Department of Commerce Bureau of the Census

Program: Decennial Census – Census United States

Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data

Table: PCT012 Sex by age [Total population]  
(retrieved from <https://factfinder.census.gov>)

RefCode 100

*Center for Disease Control and Prevention*

National Center for Health Statistics

National Vital Statistics System

July 1, 2000-July 1, 2009 Revised bridged-race intercensal population estimates

(retrieved from [https://www.cdc.gov/nchs/nvss/bridged\\_race/data\\_documentation.htm](https://www.cdc.gov/nchs/nvss/bridged_race/data_documentation.htm))

RefCode 110

U.S. Department of Commerce Bureau of the Census

Program: Decennial Census – Census United States

Data Set: Census 2010 Summary File 1

Table: PCT012 Sex by age [Total population]

(retrieved from <https://factfinder.census.gov>)

RefCode 120

*Center for Disease Control and Prevention*

National Center for Health Statistics

National Vital Statistics System

Vintage 2016 bridged-race postcensal population estimates

(retrieved from

[https://www.cdc.gov/nchs/nvss/bridged\\_race/data\\_documentation.htm#vintage2016](https://www.cdc.gov/nchs/nvss/bridged_race/data_documentation.htm#vintage2016))

RefCode 200

US Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics, United States. Vital Statistics of the United States, Volume 1-Natality. Live Births by Specified Race and Sex: United States and Each State.

(retrieved from [https://www.cdc.gov/nchs/products/vsus/vsus\\_1939\\_1964.htm](https://www.cdc.gov/nchs/products/vsus/vsus_1939_1964.htm) on 14 August 2013)

RefCode 210

US Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics, United States. Vital Statistics of the United States, Volume 1-Natality. Live Births by Specified Race and Sex: United States and Each State.

(retrieved from [https://www.cdc.gov/nchs/products/vsus/vsus\\_1965\\_1979.htm](https://www.cdc.gov/nchs/products/vsus/vsus_1965_1979.htm) on 14 August 2013)

RefCode 220

US Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics, United States. Birth Data Files for 1980-2003.

(retrieved from [https://www.cdc.gov/nchs/data\\_access/vitalstatsonline.htm](https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm) on 22 April 2015)

RefCode 230

United States Department of Health and Human Services (US DHHS),  
Centers for Disease Control and Prevention (CDC),  
National Center for Health Statistics (NCHS),  
Division of Vital Statistics (DVS),  
Nativity public-use data on CDC WONDER Online Database,  
for years 2003-2006 available March 2009  
(retrieved from <https://wonder.cdc.gov/nativity-v2006.html> on 30-July-2015)

RefCode 240

United States Department of Health and Human Services (US DHHS),  
Centers for Disease Control and Prevention (CDC),  
National Center for Health Statistics (NCHS),  
Division of Vital Statistics (DVS),  
Nativity public-use data on CDC WONDER Online Database,  
for years 2007-2016 available February 2018  
(retrieved from <https://wonder.cdc.gov/nativity-current.html> on 14-September-2017)