Add Health
The National Longitudinal Study of Adolescent to Adult Health

Add Health as a Resource for the Science of the Exposome:

Roadway Proximity / Density

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This user guide is one in a set of user guides focusing on the built, environmental, and natural features of geopositioned/geocoded Add Health respondent locations over Waves I-VI. Collectively, they describe exposomic measures in the following three domains:

Built Domain	**Environmental Domain**	**Natural Domain**
Commuting Area	Ambient Air	Altitude
Land Use	Indoor Air	Meteorology
Roadway Proximity/Density	Noise	Green space
	Waterborne Lead	Blue space
	Nighttime Light Pollution	
	Solar Irradiation	

Under the Built Domain, this particular user guide summarizes the rationale for the latest construction and assignment of roadway proximity and density. It also documents how the roadway source data were acquired, as well as the protocol for quality controlling their measurement and classification across waves. Whenever possible, construction, measurement, and classification were harmonized to ensure temporal comparability.

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Important Note: The above acknowledgement should be included in all presentations and publications using exposome data from Wave VI of Add Health.

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1. Introduction

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is a nationally representative sample of U.S. adolescents who were in grades 7-12 during the 1994-1995 school year. Using a complex, school-based cluster-sampling frame, researchers selected high school and feeder school pairs from 80 communities across the United States and drew a sex- and grade-stratified random sample of 20,745 adolescents for inclusion in the study. This sample has been followed from adolescence into early midlife across six waves of data collection to date, with the most recent wave of data collection (Wave VI) taking place between 2022 and 2025 when respondents were ages 39 to 49.

Over the years, Add Health has collected a wealth of information from respondents and their parents about demographic characteristics, familial structures, social relationships, health behaviors, cognition, physical and mental health status, medication usage, and health care access. Add Health also has collected anthropometric, cardiovascular, metabolic, renal, hepatic, inflammatory/immune, infectious, neurodegenerative, and multi-omic biomarkers from respondents. In addition, Add Health has merged multilevel contextual data about the economic, school, neighborhood, policy, and environmental contexts in which the respondents are embedded to the core survey and biological data at each wave. The Add Health dataset thereby provides researchers with rich opportunities to explore the causes and consequences of health status across multiple contextual domains as individuals age across the life course.

This user guide is one in a series documenting the latest contextual and environmental data assembled under the exposome supplement introduced in the preceding acknowledgment. Collectively, the supplemental data and documentation enable researchers to examine a broader array of built, environmental, and natural exposures linked to accurately geopositioned/geocoded Add Health respondent residences from Wave I through Wave VI. Because Wave VI data are not ready for geocoding or dissemination at present, this user guide and the associated data are focused on Wave I-V linkages. The Add Health Team will update this data set and user guide when Wave VI data are available for dissemination.

2.General Overview

The roadway proximity and density measures include distances to and summed lengths of primary and secondary roads in geocoded respondent residence-centric buffers of varying size. The data file including them is based on national-level data on major roads from ESRI StreetMap and Data & Maps. The rationale for and utility of acquiring the roadway proximity and density measures is described below.

2.1 Rationale

Since its inception, Add Health has continued amassing and disseminating contextual data files across multiple levels of geography, thus resulting in an increasingly comprehensive and diverse set of contextual measures in a nationally representative study spanning adolescence to mid adulthood. In general, these data have been provided to establish infrastructure for research addressing the role of diverse exposures across multiple levels and across the life course in the etiology and disparities of our most pressing health issues. The data collectively position Add Health as a central resource for scientists to more effectively operationalize and study the exposome and its consequences for population health across the life course, with particular attention to disparities across population subgroups.

2.2 Utility

The roadway data described herein expand the contextual data available to Add Health researchers, enhancing their capacity to examine the social, environmental, and biological dimensions of the exposome and how they contribute to U.S. population health and disparities. The roadway data may be valuable to researchers who study health outcomes associated with vehicular traffic-related noise and air pollution because proximity to and density of major roads are often used as proxies for them, especially primary air pollutants emitted directly into the air by automobiles. Examples of these include gases like nitrogen oxides (NOx) and small-diameter particulate matter (PM)[1] which have established associations with pulmonary,[2-3] cardiovascular,[4] and cerebrovascular diseases;[5] cancer,[3,6-7] birth outcomes,[8] and mental health.[9]

3. Processing Details

3.1 Assessment of Road Network Datasets

The national-level data on which roadway proximity and density are based correspond to the years of respondent residential addresses. From 1994 to 2012, there are two primary types of street data sources: major roads from ESRI Data & Maps and detailed streets from the ESRI StreetMap and North American Atlas products. For subsequent years, the data source is the major roads layer from the ESRI StreetMap Business Analyst product. See Table 1 for a listing of which road network dataset was used for each of the respondent residential address calendar years.

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Table 1. Road Network Datasets[10-20]

Participant Years	Road Network Data Set	Ground Date*
1994-2000	StreetMap 2000	1998-1999
2001-2002	ESRI Data & Maps 2003	2001-2002
2003	StreetMap 2007	2003
2004	ESRI Data & Maps 2005	2004
2005	ESRI Data & Maps 2006	2005
2006	ESRI Data & Maps 2007	2006
2007-2008	StreetMap 2012	2007
2009	StreetMap 2013	2009
2010-2013	StreetMap Premium 2010	2010
2014-2017	StreetMap Premium 2017 (Business Analyst)	2017
2018-2019	StreetMap Premium 2019 (Business Analyst)	2018

***Ground dates are based on documentation provided with data sets.**

3.2 Refinement of Respondent Locations

The geocoded address date ranges were right-censored after known death dates. Using 2010 Census block group boundaries, a check was implemented to identify any respondents whose geocoded locations placed them in bodies of water (i.e., block groups with no land area) for the purpose of "snapping" them (i.e., moving to the edge of) the nearest block group on land. There was one respondent in water that required moving or "snapping" the corresponding location to the edge of the nearest block group.

3.3 Preparation of Road Network Data Sets

The primary and secondary roads, which are those with Census Feature Classification Codes (CFCCs) beginning with A1, A2 or A3 (Appendix I), were excerpted from the eleven road network datasets (Table 1). The road network and respondent location datasets were then split into separate datasets by Universal Transverse Mercator (UTM) zone to facilitate accurate distance and summed road length calculations during geospatial processing.

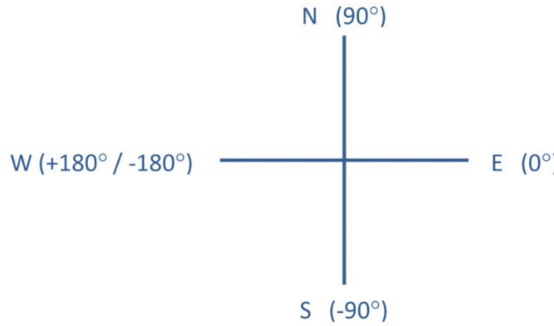
Because ESRI roads data sources changed over time with respect to (1) CFCC field names (e.g., CFCC vs. FCC vs. FUNCCLASS), (2) specific values used to designate CFCC road classes (e.g., CFCC = A1* vs. FUNCCLASS = 1 or 2), and (3) geographic coordinate systems (i.e., WGS84 geographic vs. NAD83 geographic), all roads data sources were harmonized using the steps identified below before splitting national-level files into individual UTM zones:

- Developed a crosswalk between calendar years and roads data sources;
- Expanded the crosswalk to identify the following:
  - column names in roads data sources corresponding to simplified CFCC values A1-A3
  - values used in CFCC columns to designate A1-A3
  - presence of road segments outside United States requiring exclusion
  - presence of road segments beyond A1-A3 requiring exclusion
  - coordinate system and datum for source data;
- Added a new column named FCC4QUERY to contain simplified CFCC codes (e.g., A1 instead of A11, A12, etc.);
- Isolated road segments corresponding to A1-A3 primary roads within the United States;
- Subset each roads data source by UTM zone using the WGS84 datum.

3.4 Calculation of Distance and Angle to the Nearest Road

Calculation of distance and angle to nearest primary road segments began with a Python script that used the *Generate Near Table* function in ArcGIS (Analysis toolbox) to calculate the Euclidean distance and angle to the nearest A1-A3 road for each geocoded respondent address. A ten-mile search radius was used, resulting in no distance or angle for any respondent located more than ten miles from a road.

The distances were reported in meters and the angles were reported in degrees from east (see the figure to the right). Before delivery, angles were transformed to 0-360 degrees, counterclockwise from east (between 0 and 180 when north, and between 180 and 360 when south of the geocoded respondent address).



3.5 Quality Control Checks of Distances and Angles to the Nearest Road

Initial quality control checks were performed on the distances and angles to the nearest road by verifying that the output files contained the correct number of unique respondent records. Next, verification was executed for maximum distance, reported angles, and missing value replacement codes. First, it was verified that the maximum distance was less than or equal to 16,093 meters, or 10 miles, which was the maximum search distance allowed in the processing script. Second, it was verified that all initially reported angles fell between -180 and 180. Third, it was verified that all missing value replacement codes generated by the Python geoprocessing script were correctly replaced with a dot missing (.) from the subsequent SAS script. All three quality control checks passed.

Final quality control checks were performed by first loading the respondent locations and the roads from all eleven roads datasets in ArcGIS. Then, all respondents within 16,093 meters (i.e., 10 miles) of a road were selected to verify that the selected subset matched the number of respondents with legitimate values in the output data sets. Next, there was confirmation that the minimum and maximum distance and angle values calculated by the Python script were correct. Finally, using the respondent locations and eleven road datasets in ArcGIS, there was manual verification of distance and angle to the nearest road from a sample of sixty respondents randomly selected using SAS proc surveyselect. All quality control checks passed.

3.6 Calculation of Summed Road Lengths within Euclidean Buffers

A Python script was written that created Euclidean buffers with a radius of 100 to 500 meters in 100-meter increments around each respondent's geocoded address using the *MultipleRingBuffer* tool (Analysis toolbox). A second Python script was written that used the *Intersect* tool (Analysis toolbox) in ArcGIS to overlay the respondent buffers with the eleven different road network data sets, and clipped out all road features that fell within each buffer. The script generated a text file for each road network dataset, with one record for every clipped road feature within a radius-specific, respondent residence-centric buffer. To identify records unique to each residential address range, the text files contained the UTM zone number, respondent ID, residential date from, residential date to, CFCC code, radius of the buffer used to clip the road feature, and the length in meters of the clipped road.

These text files were brought into SAS where they were reduced to a dataset of summed road lengths, with one record per respondent for a given residential date range. The final dataset was merged onto the other SAS data set containing the distances and angles to the nearest road.

3.7 Quality Control Checks of Summed Road Lengths

The overall completeness and accuracy of the final dataset were verified based on a series of checks run using SAS software. The checks were as follows:

1. Verified that the final output file had the correct number or respondents; that the file was sorted by respondent ID, date from, and date to; that all variables were included in the final dataset; and that labels were clear and succinct.
2. Ran a proc means to look for values that were out of the expected range.
3. Verified that replacement codes had been set correctly (Section 4).

In addition to the SAS checks, there were several quality control checks executed using ArcGIS Desktop 10.8.1:

1. Verified the accuracy of some of the high and low values identified in the SAS proc means query run in SAS check 2 (see above). Started with minimum and maximum values in the SAS output file and used ArcGIS to find the matching respondents and manually verify the calculations.
2. Performed spot checks by UTM zone and roads data source in order to detect any errors associated with the batch processing approach employed to generate the spatial variables. Conducted these checks by (a) manually calculating variables using the ArcGIS intersect command and (b) verifying that the manually calculated values matched those in the final output file.
3. Performed spot checks based on a sample of 60 respondents randomly selected using SAS proc surveyselect.
4. Verified the accuracy of calculations for the single respondent with all A3 summed length variables set to zero, but with a distance to the nearest A3 road of 499. Upon inspection, there was a road segment within the 500-meter radius buffer used for analysis, but the total length of the road segment was so small that it had been rounded down to zero.
5. Verified the accuracy of the calculations for a few of the many respondents with no A1*, A2* or A3* roads within 10 miles.

All quality control checks confirmed the accuracy of the output calculations with respect to the source data sets. After the successful completion of quality control checks, date ranges for successive records were consolidated when all distance, angle, and summed road length values remained the same.

3.8 Quality Control: Effects of Address Geocoding Errors

Random samples of geocoded respondent address coordinates were perturbed over a uniform distribution of directions (range, 0-360°) and distances (range, 0-500m) chosen to approximate the distribution of known geocoding errors observed among street-type address matches in this context.[21] Effects of the perturbation on the basic Euclidean and areal measures related to A1 roadways are illustrated below (Appendix II). Absolute effects of even the highest mean (431 m) perturbation were small, particularly for mean (5^{th}-95^{th} percentile) distances to the nearest roadway: 4,008 (191-16,093) v. 4,015 (260-16,093) meters. Although the ratio of mean roadway lengths before and after the 431 m perturbation was relatively large and varied inversely with size of the geocoded address-centric buffer (3.3 v. 1.8 v. 1.4 v. 1.3 v. 1.1 in buffers of radius 100 v. 200 v. 300 v. 400 v. 500 meters), it also decreased with decreasing size of the perturbation. Collectively, these findings argue for greater reliance on estimated distance to the nearest roadway and summed roadway lengths in larger geocoded, address-centric buffers as putative surrogates for traffic-related exposures.

4. Missing codes

When respondent residential location coordinates were missing and otherwise there was no way to assign possible exposures, *-9990* was used to indicate missing roadway codes. In the instance that respondent residential location coordinates were available, but there were no roadways within the 10-mile search radius, a replacement code of *-9987* was assigned for the distance and angle values. Additionally, for instances that respondent residential location coordinates were available, but there were no roadways within the 100- to 500-meter search radii, a replacement code of *0 (number zero)* was assigned for summed road lengths.

5. Data File

5.1 Structure

The roadway proximity and density data file is provided as a multiple-records-per-respondent long file comprised of 24 variables linked to 197,963 observations. The data file including these observations is based on national-level data on major roads for respondent years ranging from 1994 to 2019. Consistent with Add Health data, the 20,745 Add Health Wave I respondents are identified by a masked respondent identifier (AID) at every time period during their follow-up as presented by the date from (RMEROADSDFR) and date to (RMEROADSDTO) variables establishing the start and end of each period. Please consult the accompanying codebook for additional details.

5.2 Contents

The roadway proximity and density data file includes the variables below, which are described in the corresponding codebook documentation that also contains frequencies.

Roadway Proximity / Density Data File Contents

Variable Name	Variable Description
AID	Add Health Respondent Location ID
RMEROADSDFR	Roads Date from
RMEROADSDTO	Roads Date to
RMEROADS001	Distance to nearest A1 roadway (m)
RMEROADS002	Angle to nearest A1 roadway (degrees)
RMEROADS003	Summed A1 roadway length (m) within 100-m radius buffer
RMEROADS004	Summed A1 roadway length (m) within 200-m radius buffer
RMEROADS005	Summed A1 roadway length (m) within 300-m radius buffer
RMEROADS006	Summed A1 roadway length (m) within 400-m radius buffer
RMEROADS007	Summed A1 roadway length (m) within 500-m radius buffer
RMEROADS008	Distance to nearest A2 roadway (m)
RMEROADS009	Angle to nearest A2 roadway (degrees)
RMEROADS010	Summed A2 roadway length (m) within 100-m radius buffer

RMEROADS011	Summed A2 roadway length (m) within 200-m radius buffer
RMEROADS012	Summed A2 roadway length (m) within 300-m radius buffer
RMEROADS013	Summed A2 roadway length (m) within 400-m radius buffer
RMEROADS014	Summed A2 roadway length (m) within 500-m radius buffer
RMEROADS015	Distance to nearest A3 roadway (m)
RMEROADS016	Angle to nearest A3 roadway (degrees)
RMEROADS017	Summed A3 roadway length (m) within 100-m radius buffer
RMEROADS018	Summed A3 roadway length (m) within 200-m radius buffer
RMEROADS019	Summed A3 roadway length (m) within 300-m radius buffer
RMEROADS020	Summed A3 roadway length (m) within 400-m radius buffer
RMEROADS021	Summed A3 roadway length (m) within 500-m radius buffer

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Appendix I: List of Census Feature Class Codes (CFCCs)[22]

A10 Primary road with limited access or interstate highway, major category
A11 Primary road with limited access or interstate highway, unseparated
A12 Primary road with limited access or interstate highway, unseparated, in tunnel
A13 Primary road with limited access or interstate highway, unseparated, underpassing
A14 Primary road with limited access or interstate highway, unseparated, with rail line in center
A15 Primary road with limited access or interstate highway, separated
A16 Primary road with limited access or interstate highway, separated, in tunnel
A17 Primary road with limited access or interstate highway, separated, underpassing
A18 Primary road with limited access or interstate highway, separated, with rail line in center
A20 Primary road without limited access, U.S. and state highway, major category
A21 Primary road without limited access, U.S. and state highways, unseparated
A22 Primary road without limited access, U.S. and state highways, unseparated, in tunnel
A23 Primary road without limited access, U.S. and state highways, unseparated, underpassing
A24 Primary road without limited access, U.S. and state highways, unseparated, with rail line in center
A25 Primary road without limited access, U.S. and state highways, separated
A26 Primary road without limited access, U.S. and state highways, separated, in tunnel
A27 Primary road without limited access, U.S. and state highways, separated, underpassing
A28 Primary road without limited access, U.S. and state highways, separated, with rail line in center
A30 Secondary and connecting road, state and county highways, major category
A31 Secondary and connecting road, state and county highways, unseparated
A32 Secondary and connecting road, state and county highways, unseparated, in tunnel
A33 Secondary and connecting road, state and county highways, unseparated, underpassing
A34 Secondary and connecting road, state and county highways, unseparated, with rail line in center
A35 Secondary and connecting road, state and county highways, separated
A36 Secondary and connecting road, state and county highways, separated, in tunnel
A37 Secondary and connecting road, state and county highways, separated, underpassing
A38 Secondary and connecting road, state and county highway, separated, with rail line in center
A40 Local, neighborhood, and rural road, city street, major category
A41 Local, neighborhood, and rural road, city street, unseparated
A42 Local, neighborhood, and rural road, city street, unseparated, in tunnel
A43 Local, neighborhood, and rural road, city street, unseparated, underpassing
A44 Local, neighborhood, and rural road, city street, unseparated, with rail line in center
A45 Local, neighborhood, and rural road, city street, separated
A46 Local, neighborhood, and rural road, city street, separated, in tunnel
A47 Local, neighborhood, and rural road, city street, separated, underpassing
A48 Local, neighborhood, and rural road, city street, separated, with rail line in center
A50 Vehicular trail, road passable only by four-wheel drive (4WD) vehicle, major category
A51 Vehicular trail, road passable only by 4WD vehicle, unseparated
A52 Vehicular trail, road passable only by 4WD vehicle, unseparated, in tunnel
A53 Vehicular trail, road passable only by 4WD vehicle, unseparated, underpassing
A60 Special road feature, major category used when the minor category could not be determined
A61 Cul-de-sac, the closed end of a road that forms a loop or turn around
A62 Traffic circle, the portion of a road or intersection of roads that form a roundabout
A63 Access ramp, the portion of a road that forms a cloverleaf or limited access interchange
A64 Service drive, road that provides access to businesses, facilities, and rest areas along limited-access highway
A65 Ferry crossing, the representation of a route over water that connects roads on opposite shores

A66 Ferry crossing, Passenger, Year Round
A68 Ferry Crossing, Vehicular, Seasonal
A69 Ferry Crossing, Vehicular, Year-Round
A70 Other thoroughfare, major category used when the minor category could not be determined
A71 Walkway, nearly level road for pedestrians, usually unnamed
A72 Stairway, stepped road for pedestrians, usually unnamed
A73 Alley, road for service vehicles, usually unnamed, located at the rear of buildings and property
A74 Driveway or service road, usually privately owned and unnamed, used as access to residences, etc., or as access to logging areas, etc.
A75 Road, Parking Area

Appendix II: Effects of Address Geocoding Error on Estimation

Geocoded Address Coordinate Perturbation									Angle and Distance To Nearest A1 Roadway							Summed A1 Roadway Lengths (m) in Geocoded Address-Centric Buffer Radius =														
		Rho (m)			Theta (º)				Angle (º)				Distance (m)			100 m			200 m			300 m			400 m			500 m		
Target (m)	n	$\bar{x}$	p5	p95	$\bar{x}_{circ}$	$\bar{x}$	p5	p95	$\bar{x}_{circ}$	$\bar{x}$	p5	p95	$\bar{x}$	p5	p95	$\bar{x}$	p5	p95	$\bar{x}$	p5	p95	$\bar{x}$	p5	p95	$\bar{x}$	p5	p95	$\bar{x}$	p5	p95
0	3,374	.	.	.		.	.	.	255	178	8	344	4,098	252	16,093	4	0	0	22	0	0	56	0	523	110	0	1,181	182	0	1,712
(0, 100]	3,374	67	23	98	146	171	19	337	252	178	8	344	4,097	242	16,093	4	0	0	21	0	0	56	0	614	110	0	1,228	182	0	1,721
0	3,374	.	.	.		.	.	.	266	178	8	346	4,000	263	16,093	3	0	0	18	0	0	50	0	479	101	0	1,169	172	0	1,700
(100,200]	3,374	156	108	196	41	169	20	337	254	178	8	345	3,999	246	16,093	6	0	0	23	0	0	57	0	618	110	0	1,222	181	0	1,741
0	3,374	.	.	.		.	.	.	240	178	6	345	3,944	261	16,093	3	0	0	21	0	0	53	0	479	106	0	1,147	173	0	1,689
(200,300]	3,374	253	207	295	286	172	19	337	236	180	8	346	3,943	230	16,093	7	0	0	28	0	0	62	0	668	116	0	1,255	188	0	1,768
0	3,374	.	.	.		.	.	.	288	175	4	345	4,045	253	16,093	3	0	0	18	0	0	53	0	570	100	0	1,208	167	0	1,725
(300,400]	3,374	347	304	393	210	169	19	336	253	176	6	347	4,039	219	16,093	7	0	0	28	0	0	65	0	760	114	0	1,289	183	0	1,766
0	3,374	.	.	.		.	.	.	205	176	7	342	4,015	260	16,093	3	0	0	18	0	0	50	0	392	99	0	1,139	170	0	1,666
(400,500]	3,374	431	402	475	193	166	20	332	203	176	9	344	4,008	191	16,093	10	0	0	33	0	112	69	0	841	124	0	1,379	193	0	1,849