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# GREAT BRITAIN ACCESSIBILITY INDICATORS 2023: DATA DESCRIPTOR

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## Abstract

The dataset described in this paper introduces a suite of updated accessibility indicators to key services for Great Britain (Great Britain Accessibility Indicators 2023, AI23), expanding on the previous Public Transport Accessibility Indicators (PTAI22). AI23 enhances previous versions by incorporating walking and cycling modes, disaggregating employment accessibility by industry, adding pharmacies, and extending public transport assessments to evening off-peak times. AI23 facilitates seamless integration into varied analyses given the use of small-area official geographies.

**Keywords** Accessibility · Transport · Active travel · Health · Employment

## 1 Background & Summary

Accessibility indicators measure the ease of reaching valuable destinations (Levinson and Wu 2020). The current dataset, Great Britain Accessibility Indicators 2023 (AI23), provides small-area indicators to key services such as health, education, employment, and urban centres. This dataset is an updated and expanded version of the the Public Transport Accessibility Indicators for Great Britain 2022 (PTAI22) dataset described here: <https://zenodo.org/records/6759240> (Verduzco Torres and McArthur 2022).

The data described here represent a snapshot from the first quarter of 2023, whereas the PTAI22 corresponds to the last quarter of 2021. Where applicable, the AI23 indicators are directly comparable with the previous version. The AI23 has been expanded from the PTAI22 in the following ways:

- It includes active modes, specifically walking and cycling, in addition to public transport.
- Accessibility to employment is now disaggregated by the UK Standard Industrial Classification of Economic Activities (UK SIC).
- Pharmacies have been added as an additional health destination in the AI23 dataset.
- The public transport indicators now cover not only the morning peak but also the evening off-peak period.

In particular, the current dataset provides a suite of ready-to-use accessibility indicators to key services such as employment, general practices (GPs), hospitals, pharmacies, primary and secondary schools, supermarkets, main urban centres, and urban sub-centres. These indicators are available for 42,000 small area units across Great Britain, specifically at the Lower Super Output Area (LSOA) level in England and Wales, and the Data Zone (DZ) level in Scotland.

Accessibility indicators have been used in research to examine a broad array of regional and urban issues, including unemployment rates in the labour market (Bastiaanssen, Johnson, and Lucas 2022), vaccination

uptake in public health (Chen et al. 2023), and residential property prices (Verduzco Torres 2023a). Similarly, their relevance in planning and policymaking is increasing, serving as input for developing comprehensive project appraisals (Cavallaro, Bruzzone, and Nocera 2023), conducting 20-minute neighbourhood analyses, and as a performance benchmark.

## 2 Methods

The methods and sources used for the current dataset largely follow those outlined in the previous version (<https://zenodo.org/records/6759240>) (Verduzco Torres and McArthur 2022). The remainder of the paper focuses on the key aspects and extensions unique to this version.

The accessibility indicators, denoted as  $A$ , are constructed using location-based measures, which encompass cumulative, relative cumulative, and dual or nearest opportunity measures. These location-based measures are calculated from an origin point  $i$  and take into account the type of opportunity  $W_k$  at potential destinations  $j$ . The cumulative measures are estimated according to the equation below.

$$A_{ik} = \sum_{j=1}^n W_{jk} f(t_{ij})$$

$$f(t_{ij}) = \begin{cases} 1 & \text{if } t_{ij} \leq \bar{t} \text{ (threshold value)} \\ 0 & \text{otherwise.} \end{cases}$$

Here, it is assumed that people deem opportunities or services as reachable if the modelled travel time between the the origin and destination,  $t_{ij}$ , is equal or shorter than given threshold,  $\bar{t}$ . All services beyond this limit are disregarded. Relative cumulative measures inputs the size of the service weighted by the total number in the region, i.e.  $W_{jk}/W_k$ . Meanwhile, the dual or nearest opportunity considers the minimum travel time to a destination where the size of the service is larger than 0. In other words, these represent the shortest travel time to the nearest facility of type  $k$ , as illustrated in the equation below.

$$A_{ik} = \min_{j=1}^n \{t_{ij} : W_{kj} > 0\}$$

The measures are computed using the **AccessUK** package for the R language v0.0.1-alpha (Verduzco Torres 2023b).

### 2.1 Origins

The population weighted centroid of each of the 41,729 LSOA/DZ are considered as the origins in accessibility measures. These correspond to the 2011 Census (version last updated in 21 December 2019 for England and Wales, and 26 March 2021 for Scotland).

### 2.2 Key services at destinations

While the indicators use the same information sources to determine the locations of services, the most recent version available for the first quarter of 2023 has been used, unless stated otherwise. Table 1 presents a summary of the total number of services across the different versions of the accessibility indicators, showing minor negative or positive fluctuations. The data for urban centres uses the same input data. Therefore, those figures remain unchanged.

#### 2.2.1 Employment

In addition to accessibility to all types of employment, the AI23 dataset offers measures disaggregated by broad industrial group according to the UK SIC (see the following URL for a detailed description of the classification used: <https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities>). Table 2 presents the UK SIC grouping equivalence with the names used for the accessibility indicators.

Table 1: Destination summary

Destination	Total in 2022 (PTAI22)	Total in 2023 (AI23)
Employment	30 067 975	30 898 620
GPs	7 887	7 756
Hospitals	1 510	1 572
Pharmacies	NA	12 983
Primary schools	19 853	19 830
Secondary schools	3 457	3 466
Supermarkets	6 478	6 392
Urban centre: Main	182	182
Urban centre: Subcentre	421	421

Table 2: Broad industrial groups abbreviation

Indicator name in the IA23	SIC broad group classification
employment_agriculture_1	1 : Agriculture, forestry & fishing (A)
employment_mining_2	2 : Mining, quarrying & utilities (B,D and E)
employment_manufacturing_3	3 : Manufacturing (C)
employment_construction_4	4 : Construction (F)
employment_motor_5	5 : Motor trades (Part G)
employment_wholesale_6	6 : Wholesale (Part G)
employment_retail_7	7 : Retail (Part G)
employment_transport_8	8 : Transport & storage (inc postal) (H)
employment_accommodation_9	9 : Accommodation & food services (I)
employment_information_10	10 : Information & communication (J)
employment_financial_11	11 : Financial & insurance (K)
employment_property_12	12 : Property (L)
employment_professional_13	13 : Professional, scientific & technical (M)
employment_business_14	14 : Business administration & support services (N)
employment_public_15	15 : Public administration & defence (O)
employment_education_16	16 : Education (P)
employment_health_17	17 : Health (Q)
employment_arts_18	18 : Arts, entertainment, recreation & other services (R,S,T and U)

### 2.2.2 Pharmacies

The location of pharmacies was obtained from official public health records. The data for England comes from the ‘Consolidated Pharmaceutical List’ corresponding to the 2023-24 quarter 1. This was manually downloaded from the NHS Data portal (<https://opendata.nhsbsa.net/dataset/consolidated-pharmaceutical-list>). The location of pharmacies in Scotland was accessed from the Public Health Scotland platform. The ‘Dispenser Details January 2023’ dataset was downloaded from the URL: <https://www.opendata.nhs.scot/dataset/dispenser-location-contact-details/resource/f44e6a10-4f1f-4ffd-9205-956944bacf95>. The information for Wales was available from NHS website. The ‘Pharmacy Chains’ dataset used corresponds to June 2023 (URL: <https://nwssp.nhs.wales/ourservices/primary-care-services/general-information/data-and-publications/pharmacies-in-wales/>). These data contain address references including the postcode, which was matched with the ONS postcode dataset to assign a corresponding LSOA/DZ code.

### 2.2.3 Hospitals

The sources and selection criterion to account for the location of hospitals remains unchanged and uses the official updated datasets except for Wales. In the latter case, the PTAI22 used the list of addresses available on the Health in Wales website (<http://www.wales.nhs.uk/>). However, this is no longer active. Thus, we used the locations obtained in January 2022.

## 2.3 Travel costs

Travel costs in the accessibility indicators  $t_{ij}$  are represented by the modelled travel time by public transport, bicycle, and walk. The AI23 use a series of all-to-all travel time matrices computed from each LSOA/DZ population weighted centroids using R5R software (Saraiva et al. 2021) for the R programming language. The main inputs used are the OpenStreetMap road and pedestrian network, bus time tables from Bus Open Data Service (BODS) (<https://www.gov.uk/transport/bus-services-routes-and-timetables>), and train time tables from the Rail Delivery Group (<https://www.raildeliverygroup.com/>). The public transport indicators are estimated for two times of departure, namely 7 a.m. and 9 p.m. on the 7th of March 2023, considering a three hours time window. Additional details are offered in a separate data descriptor [PENDING REFERENCE].

## 3 Data records

The accessibility indicators can be accessed in a series of .csv files from the following open-access repository: [PENDING]. These files are organised by the type of opportunity or service within the folder structure, and by mode within the file nomenclature, as illustrated in the directory tree diagram provided. The directory structure is as follows: `root/[NAME OF SERVICE]/access_[NAME OF SERVICE]_[MODE].csv`, with ‘pt’ denoting public transport in the ‘MODE’ segment. For clarity, the diagram does not include the disaggregated employment measures, but Appendix 1 contains a comprehensive inventory of all files within the dataset.

```
## ../output/
## +-- employment_all
## |   +-- access_employment_all_bicycle.csv
## |   +-- access_employment_all_pt.csv
## |   \-- access_employment_all_walk.csv
## +-- gp_practices
## |   +-- access_gp_practices_bicycle.csv
## |   +-- access_gp_practices_pt.csv
## |   \-- access_gp_practices_walk.csv
## +-- hospitals
## |   +-- access_hospitals_bicycle.csv
## |   +-- access_hospitals_pt.csv
## |   \-- access_hospitals_walk.csv
## +-- inventory.csv
## +-- main_bua
## |   +-- access_main_bua_bicycle.csv
## |   +-- access_main_bua_pt.csv
## |   \-- access_main_bua_walk.csv
## +-- pharmacies
## |   +-- access_pharmacies_bicycle.csv
## |   +-- access_pharmacies_pt.csv
## |   \-- access_pharmacies_walk.csv
## +-- primary_schools
## |   +-- access_primary_schools_bicycle.csv
## |   +-- access_primary_schools_pt.csv
## |   \-- access_primary_schools_walk.csv
## +-- secondary_schools
## |   +-- access_secondary_schools_bicycle.csv
## |   +-- access_secondary_schools_pt.csv
## |   \-- access_secondary_schools_walk.csv
## +-- sub_bua
## |   +-- access_sub_bua_bicycle.csv
## |   +-- access_sub_bua_pt.csv
## |   \-- access_sub_bua_walk.csv
## +-- supermarkets
## |   +-- access_supermarkets_bicycle.csv
## |   +-- access_supermarkets_pt.csv
```

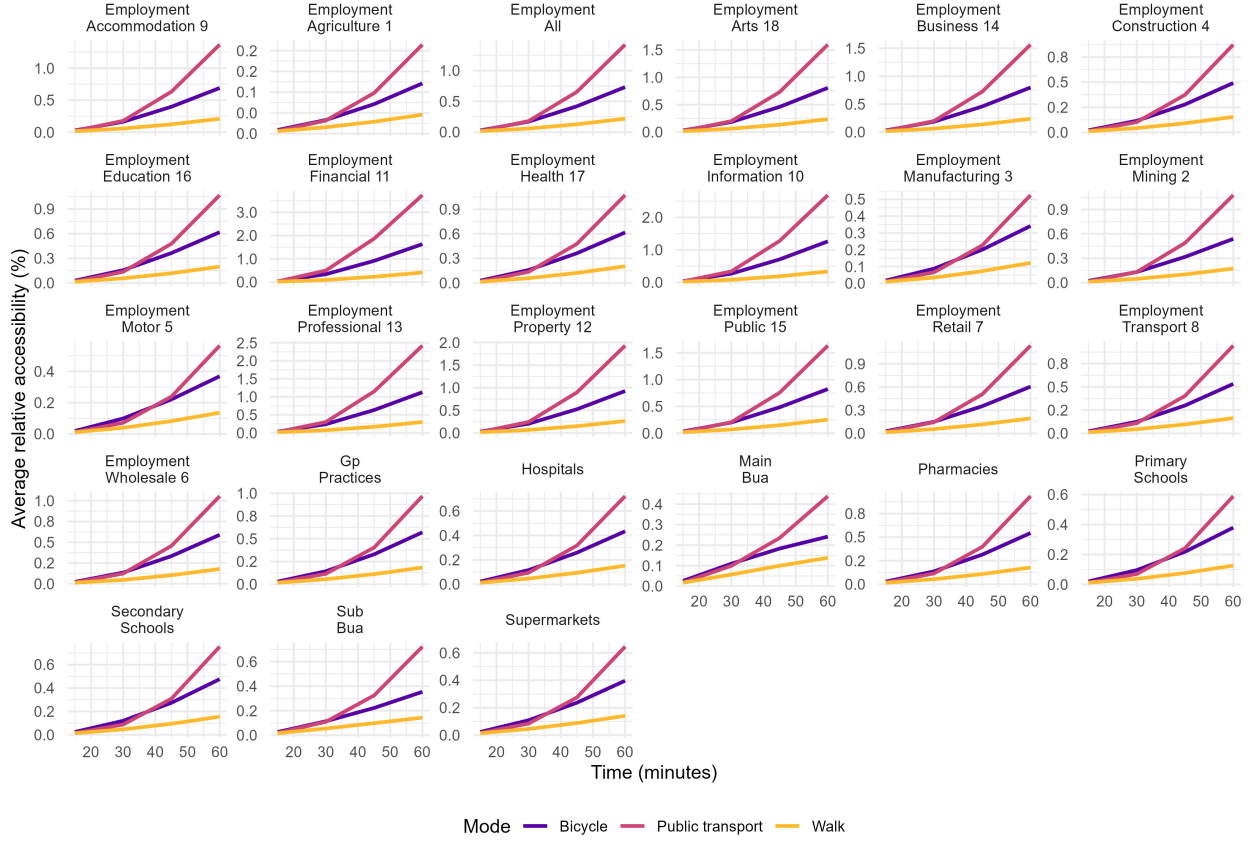


Figure 1: Relative accessibility overview to key services for various modes.

*Source:* the author based on AI23 dataset.

```
## | \-- access_supermarkets_walk.csv
## \-- variable_descriptor.csv
```

Table 3 presents the structure and contents of each file as outlined in the diagram. The first column contains the 2011 Census LSOA/DZ code. The ‘mode’ column specifies the form of transport used to calculate the indicators. The ‘time\_of\_day’ column, exclusive to public transport measures, indicates the departure time – either ‘am’ or ‘pm’ – for which the estimates are made. The prefix ‘accessibility’ in the column headers denotes cumulative measures, provided across eight 15-minute intervals ranging from 15 to 120 minutes. Relative measures are denoted by a ‘pct’ suffix. The column ‘nearest\_[NAME OF SERVICE]’ shows the travel time in minutes to the closest service of type  $k$ . This column is not applicable for employment, as these figures are aggregated from the source.

Figure 1 provides a visual summary of the relative accessibility indicators to key services by mode. The horizontal axis represents the time cut, capped at 60 minutes, while the vertical axis displays the average relative accessibility across Great Britain. The figure shows that public transport allows access to a greater number of services at longer travel times (over 45 minutes). However, for travel times less than 45 minutes, accessibility levels are similar between bicycle and public transport, and for some services within 30 minutes or less—such as Manufacturing (C) and Motor trades (Part G) employment, secondary schools, and supermarkets—accessibility is even higher for bicycle. As expected, walking is a competitive mode only at shorter distances.

Table 3: Variable descriptor

Variable	Description
geo_code	2011 LSOA/DZ geo-code of origin
mode	Mode of transport used for the indicators, values: 'pt' = public transport, 'bicycle', 'walk'
time_of_day	Time of departure, values: 'am' = 7 a.m., 'pm' = 9 p.m. Available for public transport only.
access__[NAME OF SERVICE]_15	Cumulative accessibility: Number of services of type k within 15 minutes
access__[NAME OF SERVICE]_30	Cumulative accessibility: Number of services of type k within 30 minutes
access__[NAME OF SERVICE]_45	Cumulative accessibility: Number of services of type k within 45 minutes
access__[NAME OF SERVICE]_60	Cumulative accessibility: Number of services of type k within 60 minutes
access__[NAME OF SERVICE]_75	Cumulative accessibility: Number of services of type k within 75 minutes
access__[NAME OF SERVICE]_90	Cumulative accessibility: Number of services of type k within 90 minutes
access__[NAME OF SERVICE]_105	Cumulative accessibility: Number of services of type k within 105 minutes
access__[NAME OF SERVICE]_120	Cumulative accessibility: Number of services of type k within 120 minutes
access__[NAME OF SERVICE]_15_pct	Relative cumulative accessibility: Number of services of type k within 15 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_30_pct	Relative cumulative accessibility: Number of services of type k within 30 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_45_pct	Relative cumulative accessibility: Number of services of type k within 45 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_60_pct	Relative cumulative accessibility: Number of services of type k within 60 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_75_pct	Relative cumulative accessibility: Number of services of type k within 75 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_90_pct	Relative cumulative accessibility: Number of services of type k within 90 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_105_pct	Relative cumulative accessibility: Number of services of type k within 105 minutes. In percent, from 0 to 100.
access__[NAME OF SERVICE]_120_pct	Relative cumulative accessibility: Number of services of type k within 120 minutes. In percent, from 0 to 100.
nearest__[NAME OF SERVICE]	Travel time in minutes to the nearest service of type k

## 4 Usage notes

The accessibility indicators contained in this dataset are devised for seamless integration into diverse analyses, facilitated by their alignment with an official small-area definition. They can be directly merged with other datasets at the same granularity using the 'geo\_code' identifier in standard software such as Microsoft Excel or comparable spreadsheet programs. This feature is particularly useful for assessing the actual reach of essential public services, like health and education, of distinct population segments, including vulnerable groups.

Where can more jobs be reached by bicycle than by public transport?

Map showing London at the morning peak.  
In 30 min

In 45 min

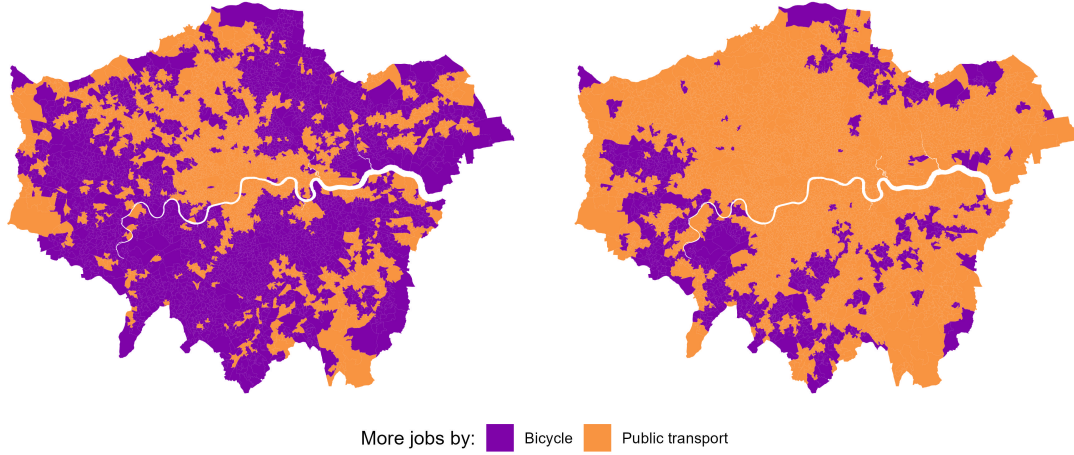


Figure 2: Accessibility to employment comparison between bicycle and public transport in London.

*Source:* the author based on AI23 dataset.

Additionally, the AI23 can be directly compared with the PTAI22 for public transport, opening up a range of possibilities for planning authorities and transport agencies to assess performance. For example, this can be useful for examining a variety of modifications ranging from simple operational adjustments such as frequencies to the introduction/discontinuation of services or physical modifications of the infrastructure. This is relevant for addressing questions such as the number of population benefited or affected, or the additional number of public services covered by public transport.

In addition to LSOA/DZ level analyses, the indicators can be aggregated at larger geographical units using the `lookup` file offered by the InFuse service (<https://infuse.ukdataservice.ac.uk/help/definitions/2011geographies/index.html>). This includes a hierarchical correspondence to mid areal unit boundaries, local authority, or region, for example.

The AI23 dataset is also valuable for conducting comparisons between sustainable transport modes. For instance, the indicators included can be used to identify communities that have the potential to increase bicycle usage by demonstrating the mode’s effectiveness relative to more conventional forms, such as public transport. Figure 2 exemplifies this for London for two time cuts, namely 30 and 45 minutes. The comparison reveals a considerable number of zones where accessibility to employment by bicycle within 30 minutes is competitive with that of public transport. The right-hand side panel shows that there are noticeably more locations with higher accessibility levels by public transport. Such inputs can be instrumental for informing demand management strategies by identifying target populations that could shift to or increase their bicycle usage, especially in areas where the public transport network experiences peak period congestion. Additionally, these insights can guide modal integration policies, favoring the development of bicycle infrastructure when it presents as a more cost-effective option than expanding public transport.

## Code availability

All the code used to generate this data set is openly available in the following GitHub repository: [https://github.com/urbanbigdatacentre/accessibility\\_indices23](https://github.com/urbanbigdatacentre/accessibility_indices23).

## Acknowledgement

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## 5 Appendix 1. Inventory of files

Table 4: Inventory of files

Path	Type	Size
./employment_accommodation_9	directory	0
./employment_accommodation_9/access_employment_accommodation_9_bicycle.csv	file	4.5M
./employment_accommodation_9/access_employment_accommodation_9_pt.csv	file	8.97M
./employment_accommodation_9/access_employment_accommodation_9_walk.csv	file	4.26M
./employment_agriculture_1	directory	0
./employment_agriculture_1/access_employment_agriculture_1_bicycle.csv	file	3.47M
./employment_agriculture_1/access_employment_agriculture_1_pt.csv	file	6.82M
./employment_agriculture_1/access_employment_agriculture_1_walk.csv	file	3.06M
./employment_all	directory	0
./employment_all/access_employment_all_bicycle.csv	file	4.87M
./employment_all/access_employment_all_pt.csv	file	9.71M
./employment_all/access_employment_all_walk.csv	file	4.64M
./employment_arts_18	directory	0
./employment_arts_18/access_employment_arts_18_bicycle.csv	file	4.42M
./employment_arts_18/access_employment_arts_18_pt.csv	file	8.81M
./employment_arts_18/access_employment_arts_18_walk.csv	file	4.17M
./employment_business_14	directory	0
./employment_business_14/access_employment_business_14_bicycle.csv	file	4.48M
./employment_business_14/access_employment_business_14_pt.csv	file	8.93M
./employment_business_14/access_employment_business_14_walk.csv	file	4.23M
./employment_construction_4	directory	0
./employment_construction_4/access_employment_construction_4_bicycle.csv	file	4.45M
./employment_construction_4/access_employment_construction_4_pt.csv	file	8.85M
./employment_construction_4/access_employment_construction_4_walk.csv	file	4.23M
./employment_education_16	directory	0
./employment_education_16/access_employment_education_16_bicycle.csv	file	4.51M
./employment_education_16/access_employment_education_16_pt.csv	file	8.98M
./employment_education_16/access_employment_education_16_walk.csv	file	4.28M
./employment_financial_11	directory	0
./employment_financial_11/access_employment_financial_11_bicycle.csv	file	4.14M
./employment_financial_11/access_employment_financial_11_pt.csv	file	8.3M
./employment_financial_11/access_employment_financial_11_walk.csv	file	3.82M
./employment_health_17	directory	0
./employment_health_17/access_employment_health_17_bicycle.csv	file	4.56M
./employment_health_17/access_employment_health_17_pt.csv	file	9.06M
./employment_health_17/access_employment_health_17_walk.csv	file	4.32M
./employment_information_10	directory	0
./employment_information_10/access_employment_information_10_bicycle.csv	file	4.3M
./employment_information_10/access_employment_information_10_pt.csv	file	8.6M
./employment_information_10/access_employment_information_10_walk.csv	file	4.03M
./employment_manufacturing_3	directory	0
./employment_manufacturing_3/access_employment_manufacturing_3_bicycle.csv	file	4.43M
./employment_manufacturing_3/access_employment_manufacturing_3_pt.csv	file	8.74M
./employment_manufacturing_3/access_employment_manufacturing_3_walk.csv	file	4.18M
./employment_mining_2	directory	0
./employment_mining_2/access_employment_mining_2_bicycle.csv	file	4.04M
./employment_mining_2/access_employment_mining_2_pt.csv	file	2.88M
./employment_mining_2/access_employment_mining_2_walk.csv	file	3.73M
./employment_motor_5	directory	0
./employment_motor_5/access_employment_motor_5_bicycle.csv	file	4.24M
./employment_motor_5/access_employment_motor_5_pt.csv	file	8.38M
./employment_motor_5/access_employment_motor_5_walk.csv	file	4M
./employment_professional_13	directory	0



Table 4: Inventory of files (*continued*)

Path	Type	Size
./employment_professional_13/access_employment_professional_13_bicycle.csv	file	4.48M
./employment_professional_13/access_employment_professional_13_pt.csv	file	8.94M
./employment_professional_13/access_employment_professional_13_walk.csv	file	4.24M
./employment_property_12	directory	0
./employment_property_12/access_employment_property_12_bicycle.csv	file	4.23M
./employment_property_12/access_employment_property_12_pt.csv	file	8.45M
./employment_property_12/access_employment_property_12_walk.csv	file	3.96M
./employment_public_15	directory	0
./employment_public_15/access_employment_public_15_bicycle.csv	file	4.26M
./employment_public_15/access_employment_public_15_pt.csv	file	8.46M
./employment_public_15/access_employment_public_15_walk.csv	file	3.94M
./employment_retail_7	directory	0
./employment_retail_7/access_employment_retail_7_bicycle.csv	file	4.52M
./employment_retail_7/access_employment_retail_7_pt.csv	file	9.01M
./employment_retail_7/access_employment_retail_7_walk.csv	file	4.29M
./employment_transport_8	directory	0
./employment_transport_8/access_employment_transport_8_bicycle.csv	file	4.37M
./employment_transport_8/access_employment_transport_8_pt.csv	file	8.67M
./employment_transport_8/access_employment_transport_8_walk.csv	file	4.11M
./employment_wholesale_6	directory	0
./employment_wholesale_6/access_employment_wholesale_6_bicycle.csv	file	4.31M
./employment_wholesale_6/access_employment_wholesale_6_pt.csv	file	8.54M
./employment_wholesale_6/access_employment_wholesale_6_walk.csv	file	4.04M
./gp_practices	directory	0
./gp_practices/access_gp_practices_bicycle.csv	file	3.78M
./gp_practices/access_gp_practices_pt.csv	file	7.49M
./gp_practices/access_gp_practices_walk.csv	file	3.54M
./hospitals	directory	0
./hospitals/access_hospitals_bicycle.csv	file	3.39M
./hospitals/access_hospitals_pt.csv	file	6.68M
./hospitals/access_hospitals_walk.csv	file	3.07M
./inventory.csv	file	6.89K
./main_bua	directory	0
./main_bua/access_main_bua_bicycle.csv	file	2.82M
./main_bua/access_main_bua_pt.csv	file	5.89M
./main_bua/access_main_bua_walk.csv	file	2.43M
./pharmacies	directory	0
./pharmacies/access_pharmacies_bicycle.csv	file	4M
./pharmacies/access_pharmacies_pt.csv	file	7.9M
./pharmacies/access_pharmacies_walk.csv	file	3.83M
./primary_schools	directory	0
./primary_schools/access_primary_schools_bicycle.csv	file	3.94M
./primary_schools/access_primary_schools_pt.csv	file	7.78M
./primary_schools/access_primary_schools_walk.csv	file	3.72M
./secondary_schools	directory	0
./secondary_schools/access_secondary_schools_bicycle.csv	file	3.63M
./secondary_schools/access_secondary_schools_pt.csv	file	7.13M
./secondary_schools/access_secondary_schools_walk.csv	file	3.37M
./sub_bua	directory	0
./sub_bua/access_sub_bua_bicycle.csv	file	3.16M
./sub_bua/access_sub_bua_pt.csv	file	6.35M
./sub_bua/access_sub_bua_walk.csv	file	2.79M
./supermarkets	directory	0
./supermarkets/access_supermarkets_bicycle.csv	file	3.72M
./supermarkets/access_supermarkets_pt.csv	file	7.35M
./supermarkets/access_supermarkets_walk.csv	file	3.48M

Table 4: Inventory of files (*continued*)

Path	Type	Size
./variable_descriptor.csv	file	2.29K

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