**Executive summary**

**MLR LASSO model performance**

* The model criteria for the reference and latest updated models were compared.
* Reference model showed a better fit to the data, but the difference was marginal.
* Also, updated model seemed to be **more interesting** to highlight that trajectory of mobility reductions during national lockdown are more likely to be influenced by **place of usual residence** (i.e., where they live), relative to other explanatory variables (e, g., socioeconomic characteristics, and accessibility indicators)
* Additionally, Figure 7 (ranking the relative importance to predict the clusters) would be excluded, as the update model one did not scale from 0 to 1.

*Reference model*

|  |  |
| --- | --- |
| Model criteria information | |
| AICc (Akaike's Information Corrected Criterion) | -222.91 |
| BIC (Bayesian information criterion) | -161.18 |

*Update model including 9 binary dummies (i.e., regions of England)*

|  |  |
| --- | --- |
| Model criteria information | |
| AICc (Akaike's Information Corrected Criterion) | -236.969 |
| BIC (Bayesian information criterion) | -147.653 |

*Contents of reference model (previous one)*

* G1: Share of self-employed workers (0.71), households with one vehicle (0.35), cumulative COVID-19 infection rates before lockdown (0.24), high-income households (0.19), and percentage Other Black (0.12).
* G2: Share of high-income households (0.47), percentage Black African (0.43), households with more than three vehicles (0.39), more than three bedrooms in the house (0.30), and Hospital density per 1,000 population (0.15).
* G3: Share of medium-income households (0.38), social grade C1 (0.25), high-income households (0.23), more than three bedrooms in the house (0.25), households with one vehicle (0.04), and self-employed workers (0.02).
* G4: Share of households with more than three vehicles (0.64), self-employed workers (0.26), more than three bedrooms in the house (0.23), cumulative COVID-19 mortality rates before lockdown (0.20), and percentage Black Caribbean (0.19).

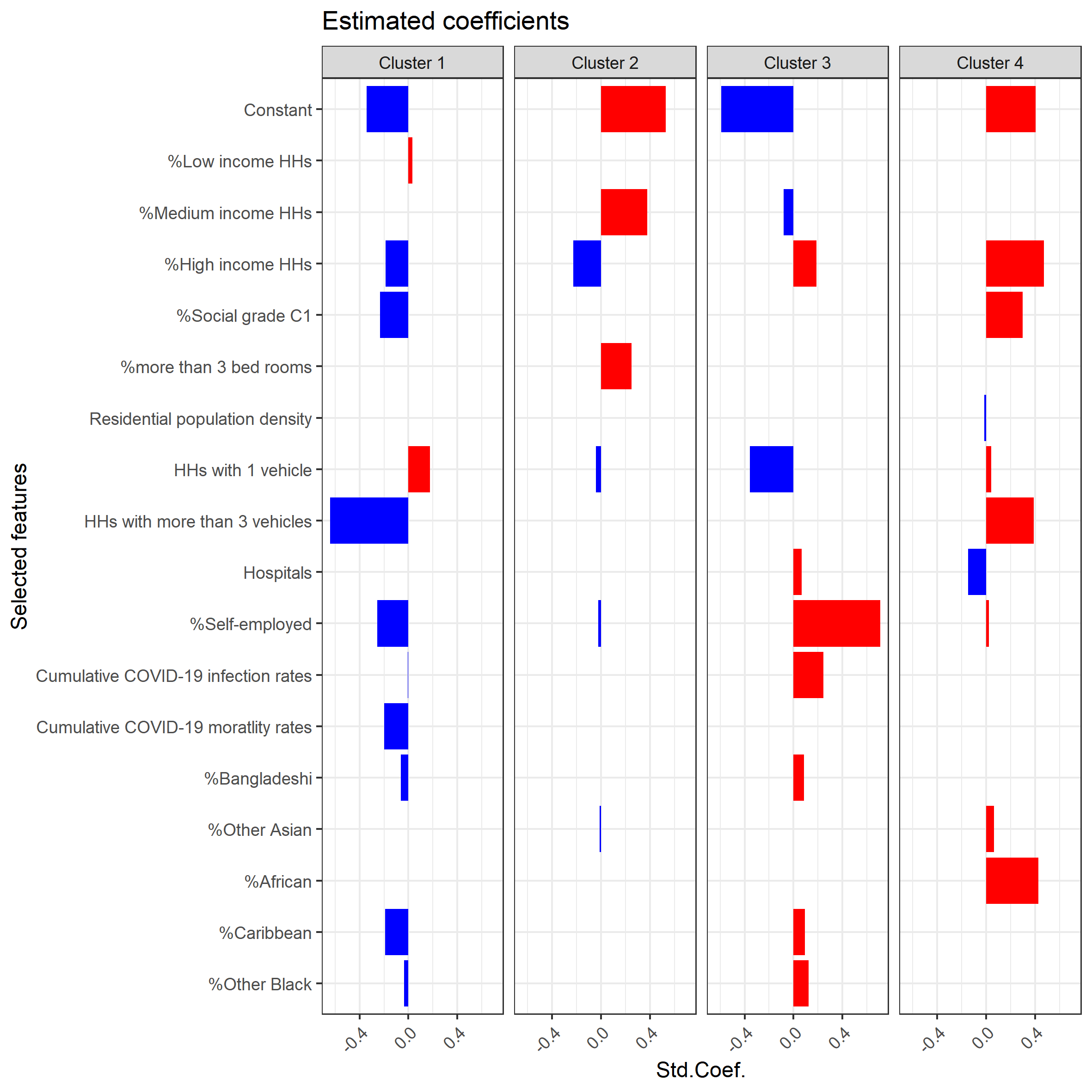


Figure 6. Estimated coefficients of explanatory variables to predict the clusters.

A graph with many squares

Description automatically generated

Figure 7. Ranking the relative feature importance to predict the clusters.

Table 3. Descriptive statistics of socioeconomic status by clusters.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Domains | | Variable | G1 | G2 | G3 | G4 | National level |
| Mean (Std.) | Mean (Std.) | Mean (Std.) | Mean (Std.) | Mean (Std.) |
| Socioeconomic | **Income** | **Share of households in lowest household**  **income quintile at national level** | **0.17 (0.02)** | **0.16 (0.02)** | **0.17 (0.02)** | **0.19 (0.03)** | **0.17 (0.02)** |
| **Share of households in median household**  **income quintile at national level** | **0.21 (0.02)** | **0.22 (0.02)** | **0.23 (0.02)** | **0.22 (0.02)** | **0.22 (0.02)** |
| **Share of households in top household**  **income quintile at national level** | **0.24 (0.07)** | **0.17 (0.05)** | **0.17 (0.05)** | **0.14 (0.04)** | **0.19 (0.07)** |
| Education and skills | Share with no qualifications | 0.19 (0.05) | 0.21 (0.04) | 0.24 (0.04) | **0.25 (0.05)** | 0.22 (0.05) |
| Share of non-English speakers | 0.11 (0.12) | 0.07 (0.07) | 0.04 (0.04) | **0.06 (0.05)** | 0.06 (0.07) |
| **Occupation** | Share of Social Grade AB  (upper middle class) | 0.37 (0.07) | 0.35 (0.07) | 0.3 (0.06) | **0.27 (0.05)** | 0.32 (0.07) |
| **Share of Social Grade C1**  **(lower middle class)** | **0.23 (0.04)** | **0.24 (0.03)** | **0.23 (0.03)** | **0.21 (0.03)** | **0.23 (0.03)** |
| Share of Social Grade C2  (skilled working class) | 0.18 (0.05) | 0.2 (0.04) | 0.23 (0.03) | **0.23 (0.03)** | 0.21 (0.04) |
| Share of Social Grade DE  (semi-skilled working class and non-working) | 0.14 (0.04) | 0.14 (0.04) | 0.16 (0.04) | **0.19 (0.05)** | 0.16 (0.05) |
| **Housing type** | Share of social rented housing | 0.18 (0.09) | 0.15 (0.06) | 0.15 (0.05) | **0.18 (0.06)** | 0.16 (0.06) |
| **Share of dwellings with ≥3 bedrooms** | **0.56 (0.15)** | **0.63 (0.07)** | **0.65 (0.06)** | **0.6 (0.06)** | **0.62 (0.09)** |
| Accessibility | **Residential density** | **Resident population density**  **(1,000 inhabitants per km2)** | **0.03 (0.04)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.02)** |
| **Car availability** | Share of households with 0 vehicle | 0.28 (0.19) | 0.19 (0.08) | 0.21 (0.07) | **0.27 (0.07)** | 0.23 (0.11) |
| **Share of households with 1 vehicle** | **0.4 (0.04)** | **0.42 (0.03)** | **0.42 (0.02)** | **0.44 (0.02)** | **0.42 (0.03)** |
| Share of households with 2 vehicles | 0.24 (0.12) | 0.29 (0.07) | 0.28 (0.05) | **0.23 (0.05)** | 0.27 (0.07) |
| **Share of households with ≥3 vehicles** | **0.02 (0.02)** | **0.03 (0.01)** | **0.02 (0.01)** | **0.01 (0.01)** | **0.02 (0.01)** |
| Clinical capacity and Allowed premises | **Hospitals (per 1,000 inhabitants)** | **0.33 (0.2)** | **0.27 (0.11)** | **0.29 (0.16)** | **0.26 (0.15)** | **0.28 (0.15)** |
| Parks (per 1,000 inhabitants) | 25.5 (10.95) | 22.87 (10.32) | 22.89 (11.82) | **21.61 (10.54)** | 22.97 (10.98) |
| Activity commitment | **Economic activity** | Share of part-time workers  in the resident population aged 16-74 | 0.13 (0.03) | 0.14 (0.01) | 0.15 (0.01) | **0.14 (0.01)** | 0.14 (0.02) |
| Share of full-time worker  in the resident population aged 16-74 | 0.39 (0.04) | 0.4 (0.04) | 0.39 (0.03) | **0.38 (0.04)** | 0.39 (0.04) |
| **Share of self-employed workers**  **in the resident population aged 16-74** | **0.13 (0.02)** | **0.11 (0.02)** | **0.1 (0.02)** | **0.08 (0.02)** | **0.1 (0.03)** |
| Population Health | General health status | Share of population in good health | 0.83 (0.02) | 0.83 (0.03) | 0.81 (0.03) | **0.8 (0.03)** | 0.82 (0.03) |
| Share of population in fair health | 0.12 (0.02) | 0.12 (0.02) | 0.14 (0.02) | **0.14 (0.02)** | 0.13 (0.02) |
| Share of population in bad health | 0.05 (0.01) | 0.05 (0.01) | 0.05 (0.01) | **0.06 (0.01)** | 0.05 (0.01) |
| Perceived risk of COVID-19 | **Infection rates** | **Cumulative COVID-19 reported cases**  **per 100,000 population before lockdown** | **24.6 (19.65)** | **15.72 (12.14)** | **11.29 (7.04)** | **9.49 (8.57)** | **14.11 (12.40)** |
| **Mortality rates** | **Cumulative COVID-19 reported deaths**  **per 100,000 population before lockdown** | **1.83 (1.87)** | **1.25 (1.44)** | **0.93 (1.26)** | **0.61 (0.81)** | **1.08 (1.39)** |
| Ethnic composition | White | Percentage of the residential population  that identified as White British | 0.82 (0.2) | 0.88 (0.14) | 0.93 (0.08) | **0.9 (0.09)** | 0.89 (0.13) |
| Mixed/multiple groups | Percentage of Mixed (joint) and  Multiple ethnic groups | 0.03 (0.02) | 0.02 (0.01) | 0.01 (0.01) | **0.02 (0.01)** | 0.02 (0.01) |
| Indian | Percentage Indian | 0.03 (0.05) | 0.02 (0.04) | 0.02 (0.03) | **0.02 (0.04)** | 0.02 (0.04) |
| Pakistani | Percentage Pakistani | 0.01 (0.02) | 0.01 (0.03) | 0.01 (0.03) | **0.02 (0.04)** | 0.01 (0.03) |
| **Bangladeshi** | **Percentage Bangladeshi** | **0.02 (0.05)** | **0 (0.01)** | **0 (0.01)** | **0 (0.01)** | **0.01 (0.02)** |
| Chinese | Percentage Chinese | 0.01 (0.01) | 0.01 (0) | 0 (0) | **0.01 (0.01)** | 0.01 (0.01) |
| **Other Asian** | **Percentage Other Asian** | **0.02 (0.03)** | **0.02 (0.02)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.02)** |
| **African** | **Percentage Black African** | **0.03 (0.04)** | **0.02 (0.03)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.02)** |
| **Caribbean** | **Percentage Black Caribbean** | **0.02 (0.03)** | **0.01 (0.02)** | **0 (0.01)** | **0 (0.01)** | **0.01 (0.02)** |
| **Other Black** | **Percentage Other Black** | **0.01 (0.01)** | **0 (0.01)** | **0 (0)** | **0 (0)** | **0 (0.01)** |
| Other ethnic groups | Percentage of any other ethnic group | 0.02 (0.02) | 0.01 (0.01) | 0 (0) | **0.01 (0.01)** | 0.01 (0.01) |

*Notes*: Variables in bold (i.e., 17 selected features) have been included in the classification model below at least in one cluster.

Table 4. Estimated coefficients of explanatory variables to classify clusters.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Domains | | Variable | G1 | G2 | G3 | G4 |
| Constant | | | -0.59 | 0.41 | 0.53 | -0.34 |
| Socioeconomic | Income | Share of households in the lowest household  income quintile at the national level |  |  |  | 0.03 |
| Share of households in median household  income quintile at the national level | -0.08 |  | 0.38 |  |
| Share of households in top household  income quintile at national level | 0.19 | 0.47 | -0.23 | -0.19 |
| Occupation | Share of Social Grade C1 (lower middle class) |  | 0.3 |  | -0.23 |
| Housing type | Share of dwellings with ≥3 bedrooms |  |  | 0.25 |  |
| Residential density | Resident population density  (1,000 inhabitants per km2) |  | -0.02 |  |  |
| Accessibility | Car availability | Share of households with 1 vehicle | -0.35 | 0.04 | -0.04 | 0.18 |
| Share of households with ≥3 vehicles |  | 0.39 |  | -0.64 |
| Clinical capacity and Allowed premises | Hospitals (per 1,000 inhabitants) | 0.07 | -0.15 |  |  |
| Activity commitment | Economic activity | Share of self-employed workers in the resident  population aged 16-74 | 0.71 | 0.02 | -0.02 | -0.26 |
| Perceived risk of COVID-19 | Infection rates | Cumulative COVID-19 reported cases per 100,000  resident population before lockdown | 0.24 |  |  | -0.01 |
| Mortality rates | Cumulative COVID-19 reported deaths per 100,000  resident population before lockdown |  |  |  | -0.2 |
| Ethnic composition | Bangladeshi | Percentage Bangladeshi | 0.08 |  |  | -0.06 |
| Other Asian | Percentage Other Asian |  | 0.06 | -0.01 |  |
| African | Percentage Black African |  | 0.43 |  |  |
| Caribbean | Percentage Black Caribbean | 0.09 |  |  | -0.19 |
| Other Black | Percentage Other Black | 0.12 |  |  | -0.03 |
| Model criteria information | | | | | | |
| AICc (Akaike's Information Corrected Criterion) | | -222.91 | | | | |
| BIC (Bayesian information criterion) | | -161.18 | | | | |

*Contents of updated model (incl. 9 dummy variables)*

* G1: residency in London (1.643), Share of self-employed workers (0.648), cumulative COVID-19 mortality rates before lockdown (0.114), Hospital density per 1,000 population (0.067), and high-income households (0.066) / households with one vehicle (-0.454), South West (-0.237), and West Midlands (-0.053)
* G2: Shre of middle-income households (0.403), North East (0.271), more than three bedrooms in the house (0.193), residency in West Midlands (0.174) / high-income households (-0.178) and self-employed workers (-0.008)
* G3: residency in Yorkshire and the Humber (1.45), South West (0.655), Share of households with more than one vehicle (0.146), East Midlands (0.085) / households with more than three vehicles (-0.634), self-employed workers (-0.438), percentage of Caribbean (-0.134), social grade C1 (-0.082), cumulative COVID-19 mortality rates before lockdown (-0.076), high-income households (-0.066)
* G4: Share of high-income households (0.451), percentage of African (0.384), social grade C1 (0.351), households with more than three vehicles (0.264), percentage of Other Asian (0.115), residency in East of England, and self-employed workers (0.008) / Hospital density per 1,000 population (-0.142)

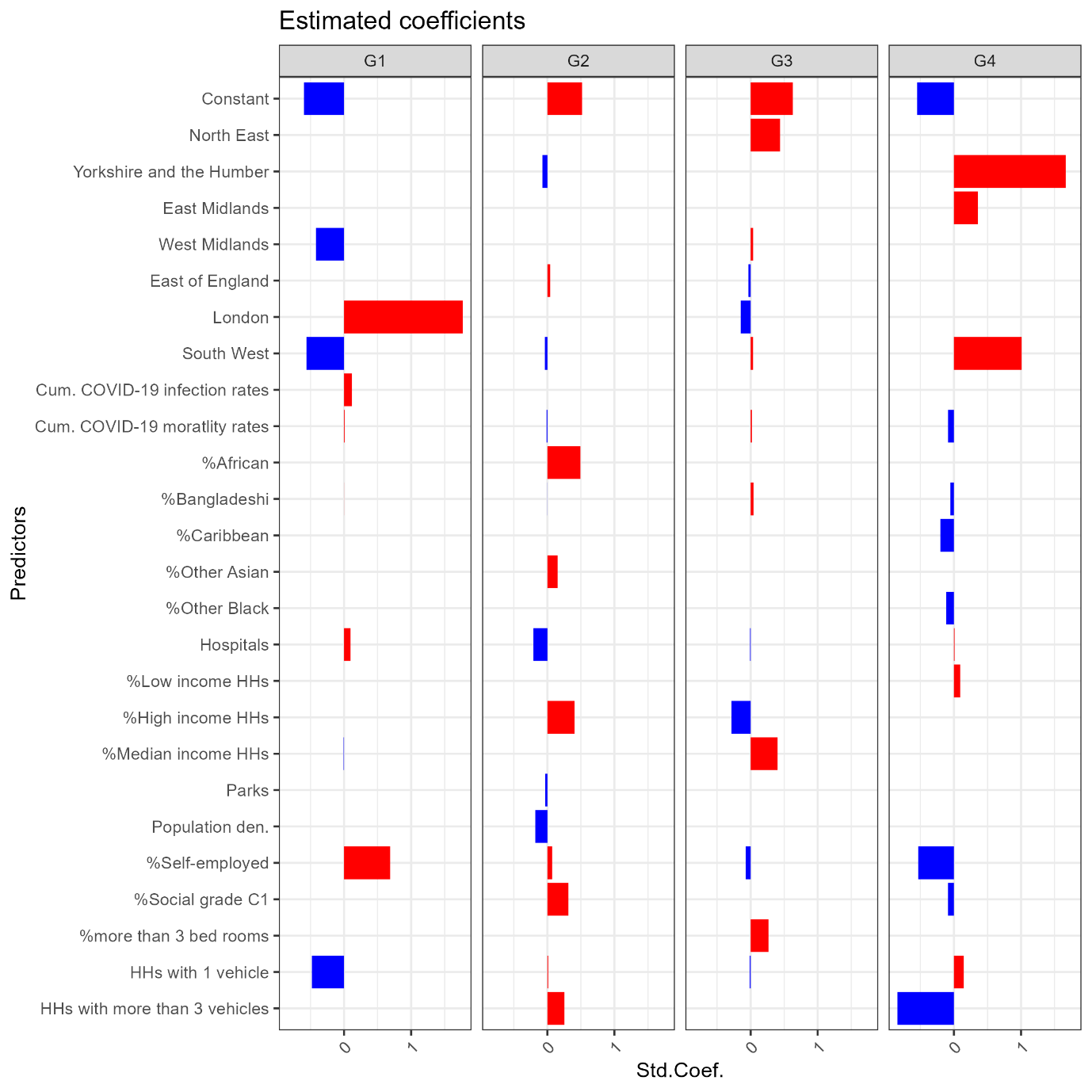


Figure 6. Estimated coefficients of explanatory variables to predict the clusters.

Table 3. Descriptive statistics of socioeconomic status by clusters.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Domains | | Variable | G1 | G2 | G3 | G4 | National level |
| Mean (Std.) | Mean (Std.) | Mean (Std.) | Mean (Std.) | Mean (Std.) |
| Socioeconomic | **Income** | **Share of households in lowest household**  **income quintile at national level** | **0.17 (0.02)** | **0.16 (0.02)** | **0.17 (0.02)** | **0.19 (0.03)** | **0.17 (0.02)** |
| **Share of households in median household**  **income quintile at national level** | **0.21 (0.02)** | **0.22 (0.02)** | **0.23 (0.02)** | **0.22 (0.02)** | **0.22 (0.02)** |
| **Share of households in top household**  **income quintile at national level** | **0.24 (0.07)** | **0.17 (0.05)** | **0.17 (0.05)** | **0.14 (0.04)** | **0.19 (0.07)** |
| Education and skills | Share with no qualifications | 0.19 (0.05) | 0.21 (0.04) | 0.24 (0.04) | 0.25 (0.05) | 0.22 (0.05) |
| Share of non-English speakers | 0.11 (0.12) | 0.07 (0.07) | 0.04 (0.04) | 0.06 (0.05) | 0.06 (0.07) |
| **Occupation** | Share of Social Grade AB  (upper middle class) | 0.37 (0.07) | 0.35 (0.07) | 0.3 (0.06) | 0.27 (0.05) | 0.32 (0.07) |
| **Share of Social Grade C1**  **(lower middle class)** | **0.23 (0.04)** | **0.24 (0.03)** | **0.23 (0.03)** | **0.21 (0.03)** | **0.23 (0.03)** |
| Share of Social Grade C2  (skilled working class) | 0.18 (0.05) | 0.2 (0.04) | 0.23 (0.03) | 0.23 (0.03) | 0.21 (0.04) |
| Share of Social Grade DE  (semi-skilled working class and non-working) | 0.14 (0.04) | 0.14 (0.04) | 0.16 (0.04) | 0.19 (0.05) | 0.16 (0.05) |
| **Housing type** | Share of social rented housing | 0.18 (0.09) | 0.15 (0.06) | 0.15 (0.05) | 0.18 (0.06) | 0.16 (0.06) |
| **Share of dwellings with ≥3 bedrooms** | **0.56 (0.15)** | **0.63 (0.07)** | **0.65 (0.06)** | **0.6 (0.06)** | **0.62 (0.09)** |
| Accessibility | **Residential density** | **Resident population density**  **(1,000 inhabitants per km2)** | **0.03 (0.04)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.02)** |
| **Car availability** | Share of households with 0 vehicle | 0.28 (0.19) | 0.19 (0.08) | 0.21 (0.07) | 0.27 (0.07) | 0.23 (0.11) |
| **Share of households with 1 vehicle** | **0.4 (0.04)** | **0.42 (0.03)** | **0.42 (0.02)** | **0.44 (0.02)** | **0.42 (0.03)** |
| Share of households with 2 vehicles | 0.24 (0.12) | 0.29 (0.07) | 0.28 (0.05) | 0.23 (0.05) | 0.27 (0.07) |
| **Share of households with ≥3 vehicles** | **0.02 (0.02)** | **0.03 (0.01)** | **0.02 (0.01)** | **0.01 (0.01)** | **0.02 (0.01)** |
| **Clinical capacity and Allowed premises** | **Hospitals (per 1,000 inhabitants)** | **0.33 (0.2)** | **0.27 (0.11)** | **0.29 (0.16)** | **0.26 (0.15)** | **0.28 (0.15)** |
| **Parks (per 1,000 inhabitants)** | **25.5 (10.95)** | **22.87 (10.32)** | **22.89 (11.82)** | **21.61 (10.54)** | **22.97 (10.98)** |
| Activity commitment | **Economic activity** | Share of part-time workers  in the resident population aged 16-74 | 0.13 (0.03) | 0.14 (0.01) | 0.15 (0.01) | 0.14 (0.01) | 0.14 (0.02) |
| Share of full-time worker  in the resident population aged 16-74 | 0.39 (0.04) | 0.4 (0.04) | 0.39 (0.03) | 0.38 (0.04) | 0.39 (0.04) |
| **Share of self-employed workers**  **in the resident population aged 16-74** | **0.13 (0.02)** | **0.11 (0.02)** | **0.1 (0.02)** | **0.08 (0.02)** | **0.1 (0.03)** |
| Population Health | General health status | Share of population in good health | 0.83 (0.02) | 0.83 (0.03) | 0.81 (0.03) | 0.8 (0.03) | 0.82 (0.03) |
| Share of population in fair health | 0.12 (0.02) | 0.12 (0.02) | 0.14 (0.02) | 0.14 (0.02) | 0.13 (0.02) |
| Share of population in bad health | 0.05 (0.01) | 0.05 (0.01) | 0.05 (0.01) | 0.06 (0.01) | 0.05 (0.01) |
| Perceived risk of COVID-19 | **Infection rates** | **Cumulative COVID-19 reported cases**  **per 100,000 population before lockdown** | **24.6 (19.65)** | **15.72 (12.14)** | **11.29 (7.04)** | **9.49 (8.57)** | **14.11 (12.40)** |
| **Mortality rates** | **Cumulative COVID-19 reported deaths**  **per 100,000 population before lockdown** | **1.83 (1.87)** | **1.25 (1.44)** | **0.93 (1.26)** | **0.61 (0.81)** | **1.08 (1.39)** |
| Ethnic composition | White | Percentage of the residential population  that identified as White British | 0.82 (0.2) | 0.88 (0.14) | 0.93 (0.08) | 0.9 (0.09) | 0.89 (0.13) |
| Mixed/multiple groups | Percentage of Mixed (joint) and  Multiple ethnic groups | 0.03 (0.02) | 0.02 (0.01) | 0.01 (0.01) | 0.02 (0.01) | 0.02 (0.01) |
| Indian | Percentage Indian | 0.03 (0.05) | 0.02 (0.04) | 0.02 (0.03) | 0.02 (0.04) | 0.02 (0.04) |
| Pakistani | Percentage Pakistani | 0.01 (0.02) | 0.01 (0.03) | 0.01 (0.03) | 0.02 (0.04) | 0.01 (0.03) |
| **Bangladeshi** | **Percentage Bangladeshi** | **0.02 (0.05)** | **0 (0.01)** | **0 (0.01)** | **0 (0.01)** | **0.01 (0.02)** |
| Chinese | Percentage Chinese | 0.01 (0.01) | 0.01 (0) | 0 (0) | 0.01 (0.01) | 0.01 (0.01) |
| **Other Asian** | **Percentage Other Asian** | **0.02 (0.03)** | **0.02 (0.02)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.02)** |
| **African** | **Percentage Black African** | **0.03 (0.04)** | **0.02 (0.03)** | **0.01 (0.01)** | **0.01 (0.01)** | **0.01 (0.02)** |
| **Caribbean** | **Percentage Black Caribbean** | **0.02 (0.03)** | **0.01 (0.02)** | **0 (0.01)** | **0 (0.01)** | **0.01 (0.02)** |
| **Other Black** | **Percentage Other Black** | **0.01 (0.01)** | **0 (0.01)** | **0 (0)** | **0 (0)** | **0 (0.01)** |
| Other ethnic groups | Percentage of any other ethnic group | 0.02 (0.02) | 0.01 (0.01) | 0 (0) | 0.01 (0.01) | 0.01 (0.01) |

*Notes*: Variables in bold (i.e., 18 selected features) have been included in the classification model with 7 regional dummy variables below at least in one cluster.

Table 4. Estimated coefficients of explanatory variables to classify clusters.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Domains** | | **Variable** | **G1** | **G2** | **G3** | **G4** |
| Constant | | | -0.597 | 0.518 | 0.628 | -0.549 |
| Regions in England | North East | |  |  | 0.439 |  |
| Yorkshire and the Humber | |  | -0.072 |  | 1.665 |
| East Midlands | |  |  |  | 0.356 |
| West Midlands | | -0.418 |  | 0.038 |  |
| East of England | |  | 0.044 | -0.034 |  |
| London | | 1.770 |  | -0.148 |  |
| South West | | -0.561 | -0.037 | 0.037 | 1.010 |
| Socioeconomic | Income | Share of households in lowest household income quintile at national level |  | 0.408 | -0.286 |  |
| Share of households in median household income quintile at national level | -0.006 |  | 0.403 |  |
| Share of households in top household income quintile at national level |  |  |  | 0.092 |
| Occupation | Share of Social Grade C1 (lower middle class) |  | 0.313 |  | -0.089 |
| Housing type | Share of dwellings with ≥3 bedrooms |  |  | 0.266 |  |
| Accessibility | Residential density | Resident population density (1,000 inhabitants per km2) |  | -0.180 |  |  |
| Car availability | Share of households with 1 vehicle | -0.479 | 0.013 | -0.013 | 0.145 |
| Share of households with ≥3 vehicles |  | 0.255 |  | -0.842 |
| Clinical capacity and  Allowed premises | Hospitals (per 1,000 inhabitants) | 0.097 | -0.206 | -0.009 | 0.009 |
| Parks (per 1,000 inhabitants) |  | -0.033 |  |  |
| Activity commitment | Economic activity | Share of self-employed workers in the resident population aged 16-74 | 0.688 | 0.073 | -0.073 | -0.533 |
| Perceived risk of COVID-19 | Infection rates | Cumulative COVID-19 reported cases per 100,000 population before lockdown | 0.117 |  |  |  |
| Mortality rates | Cumulative COVID-19 reported deaths per 100,000 population before lockdown | 0.011 | -0.011 | 0.020 | -0.088 |
| Ethnic composition | Bangladeshi | Percentage Bangladeshi | 0.001 | -0.001 | 0.043 | -0.054 |
| Other Asian | Percentage Other Asian |  | 0.153 |  |  |
| African | Percentage Black African |  | 0.493 |  |  |
| Caribbean | Percentage Black Caribbean |  |  |  | -0.203 |
| Other Black | Percentage Other Black |  |  |  | -0.114 |
| Model criteria information | | | | | | |
| AICc (Akaike's Information Corrected Criterion) | | | -236.969 | | | |
| BIC (Bayesian information criterion) | | | -147.653 | | | |