

Supplementary Appendix

Bedroom and space standard calculation methods

Bedroom standard calculation method

We estimated the bedroom standard using primary care EHRs using rules set out in the bedroom standard calculation [17, 33].

The bedroom standard states that a separate bedroom must be allocated to:

- an adult couple
- any remaining adult (aged 21 years or over)
- two adolescents (aged 10 to 20 years) of the same sex
- one adolescent (aged 10 to 20 years) and one child (aged 9 years or under) of the same sex
- two children (aged 9 years or under) regardless of sex
- any remaining child (aged 9 years or under)"

If the conditions above cannot be fulfilled with the number of bedrooms available in a dwelling, the dwelling is classified as overcrowded. We used these rules by rounding down ages to whole years.

As we did not have information regarding the relationships between people, we assigned people to first, second and third generations based on the following assumptions about the ages of and between household members.

1. We assigned people aged ≤ 19 years to the child generation.

This was based on age at the end of the calendar year in which secondary school education is usually completed. As only 5% and 1.8% of mothers and fathers respectively are aged < 20 years at the birth of their child [54], we assumed that people aged ≤ 19 years were unlikely to be parents (Supplementary Table 1). We based this on data from the 2011 Census, as data published from the 2021 Census has to date only reported the standardised mean age of mothers (30.9 years) and fathers (33.7 years) [55].

2. We assigned people to a second generation, if they were the youngest of all the non-child members and 20-50 years older than the oldest child. If no one was

assigned to this category, we reduced this minimum age difference to 19 years.

3. **We assigned partners in the second generation** based on the distribution of age differences between cohabiting or married partners [56, 57] and assuming that the age of the partner was between the age of the next youngest and ≤ 12 years older than the partner, irrespective of sex.
4. **We assigned people to a third generation, if they were ≥ 50 years than the oldest person in the first generation.** This was based on the distribution in Table 1, which shows that a very small number of parents (mainly men) are more than 45 years older than their child at birth.
5. **We assigned partners in the third generation, as in step three, by assuming that the age of the partner was between the age of the next youngest and ≤ 12 years older than the partner, irrespective of sex.**
6. **All other household members were classified as other.**

In adult-only households, the first stage was omitted and stages 2 and 5 are calculated based on a dummy first generation variable, age 1 year. All other stages remained the same.

The set of rules presented above is relatively simple and achieves the aim of imposing plausible household relationships between members, which in consequence allowed us to estimate which household members should be allocated separate rooms/bedrooms and which members could share bedrooms with assigned partners. It is important to note that observational data does not provide enough information in houses with multiple adults to differentiate between the house shares of single households, adult children living with spouses and parents, and other family set-ups. Here, we assumed that there was only one married/cohabiting couple in household per second or third generation.

Space per person calculation method

We calculated space per person by dividing the total floor area of a dwelling in the EPC record by the number of persons living in that dwelling according to the primary care EHR. We divided the distribution of space per person into four quartiles for descriptive statistics and used the continuous space per person as an outcome in multivariate models.

Supplementary Table 1: Live births by age group of mother and father, 2011

Age (years)	Mothers	Fathers
Under 20	5%	2%
20-24	19%	11%
25-29	28%	22%
30-34	29%	29%
35-39	16%	21%
40-44	4%	10%
45 and over	0%	5%

Source [54].

Supplementary Table 2a: Characteristics of overcrowded and not overcrowded households by the bedroom standard

	Not overcrowded (n)	Not overcrowded (95% CI)	Overcrowded (n)	Overcrowded (95% CI)
Child in household				
No	181,119	95.3 (95.2, 95.4)	8,953	4.7 (4.6, 4.8)
Yes	110,326	77.5 (77.3, 77.7)	32,075	22.5 (22.3, 22.7)
Household ethnicity				
White	164,663	90.9 (90.8, 91.1)	16,433	9.1 (8.9, 9.2)
South Asian	58,103	80.3 (80.0, 80.6)	14,245	19.7 (19.4, 20.0)
Black	38,804	85.4 (85.1, 85.8)	6,609	14.6 (14.2, 14.9)
Mixed, Other	23,640	86.6 (86.2, 87.0)	3,655	13.4 (13.0, 13.8)
Not known	6,235	98.6 (98.3, 98.9)	86	1.4 (1.1, 1.7)
Tenure				
Owner occupied	123,411	92.1 (92.0, 92.2)	10,591	7.9 (7.8, 8.0)
Private rented	96,490	82.5 (82.2, 82.7)	20,515	17.5 (17.3, 17.8)
Social rented	67,716	87.8 (87.6, 88.0)	9,417	12.2 (12.0, 12.4)
Unknown	3,828	88.3 (87.3, 89.3)	505	11.7 (10.7, 12.7)

Footnote: CI: Confidence Intervals.

Supplementary Table 2b: Characteristics of overcrowded and not overcrowded households by the space standard

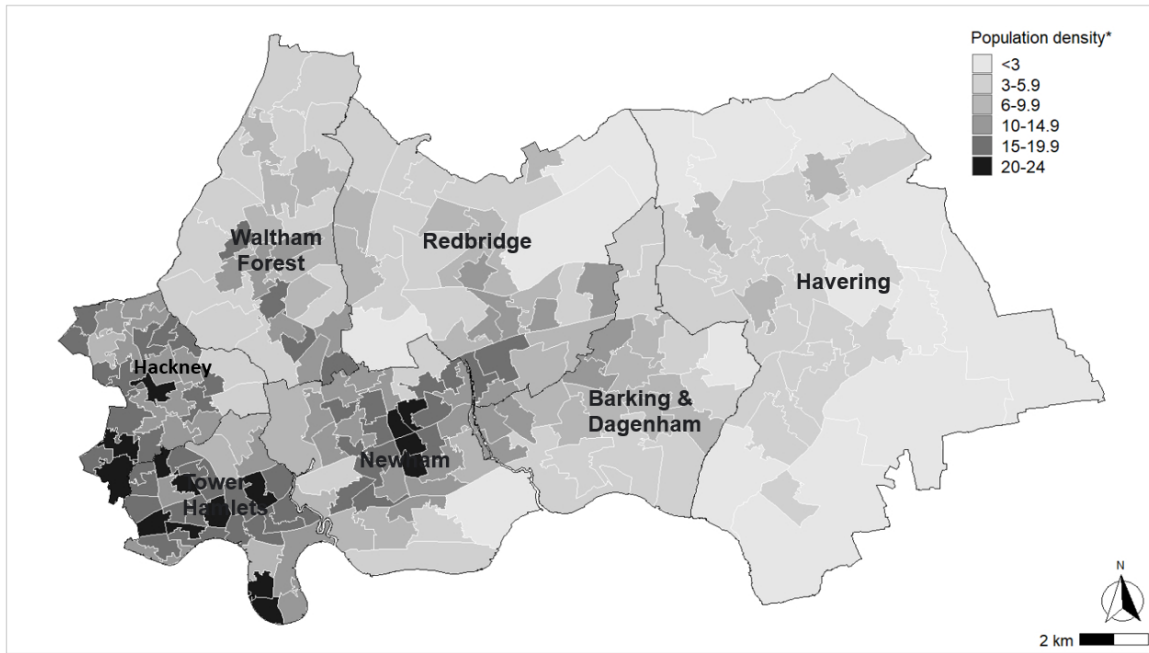
Child in household				
No	171,843	90.4 (90.3, 90.5)	18,229	9.6 (9.5, 9.7)
Yes	77,013	54.1 (53.8, 54.3)	65,388	45.9 (45.7, 46.2)
Household ethnicity				
White	147,792	81.6 (81.4, 81.8)	33,304	18.4 (18.2, 18.6)
South Asian	43,417	60.0 (59.7, 60.4)	28,931	40.0 (39.6, 40.3)
Black	31,773	70.0 (69.5, 70.4)	13,640	30.0 (29.6, 30.5)
Mixed, Other	19,912	73.0 (72.4, 73.5)	7,383	27.0 (26.5, 27.6)
Not known	5,962	94.3 (93.7, 94.9)	359	5.7 (5.1, 6.3)
Tenure				
Owner occupied	111,279	83.0 (82.8, 83.2)	22,723	17.0 (16.8, 17.2)
Private rented	77,903	66.6 (66.3, 66.9)	39,102	33.4 (33.1, 33.7)
Social rented	56,411	73.1 (72.8, 73.4)	20,722	26.9 (26.6, 27.2)
Unknown	3,263	75.3 (74.0, 76.6)	1,070	24.7 (23.4, 26.0)

Footnote: CI: Confidence Intervals.

Supplementary Table 3: Predicted average space per person for households with and without children by household ethnicity and tenure

Household ethnicity	Tenure	Space per person (m ²) Child in household	
		No	Yes
White	Owner occupied	48.7	26.1
	Social rented	41.9	19.3
	Private rented	39.7	17.1
South Asian	Owner occupied	44.8	22.2
	Social rented	38.0	15.4
	Private rented	35.8	13.2
Black	Owner occupied	46.0	23.3
	Social rented	39.2	16.6
	Private rented	37.0	14.4

Supplementary Figure 1: Population density [49]



*1000 people per square kilometre. MSOA (Middle Layer Super Output Area) boundaries are marked in white and local authority boundaries are marked in black.

