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Defining distance thresholds for migration research

Nik Lomax¹  | Paul Norman¹  | Frances Darlington-Pollock² ¹School of Geography, University of Leeds, Leeds, England²Department of Geography and Planning, University of Liverpool, Liverpool, England**Correspondence**

Nik Lomax, School of Geography, University of Leeds, Leeds, LS2 9JT, England.

Email: n.m.lomax@leeds.ac.uk

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Abstract

There exists a large body of research focused on migration distance, where migration is either the outcome of interest or used as an input variable to model something else. However, there is little consistency in the distance thresholds used: these are often arbitrary, based on administrative boundaries or constrained by definitions available in the dataset. This causes problems with comparison across studies, and in some cases where migration distance is poorly defined could lead to issues with interpretation of results. Using Binary Logistic Regression and drawing on data from the 2011 Census Sample of Anonymised Records for England and Wales, we demonstrate that the odds of migrating vary when considering a range of population characteristics across 16 distance thresholds. We argue that the choice of distance cut-offs needs to be population and context specific and that decisions about these cut-offs should be made carefully as part of the study design.

KEYWORDS

census, decision, distance, England and Wales, migration, threshold

1 | INTRODUCTION

In publishing his seven laws of migration, Ravenstein (1885) set out a series of empirical generalisations about why people move, which groups are more mobile and how the distance over which migrants travel varies widely. Subsequently, a wealth of empirical research has expanded and built upon Ravenstein's laws (Rees & Lomax, 2019), with a focus on who moves where, for what reason, and over what distance. That the motives for migration vary over distance is widely acknowledged, however, Niedomysl (2011) argues that the precise nature of this relationship between motive and distance has, to date, been under researched due to inadequate data availability and the use of surveys with fixed response options. The result is a field of study which largely defines short distance migration as motivated by housing considerations and long-distance migration as motivated by employment considerations. Yet Clark and Withers (2007) argue that this is an over simplification given how complex family formation processes are.

A further distinction is often made between shorter distance moves being thought of as *residential mobility* and longer distance moves being considered as *internal migration* (Coulter et al., 2016). This distinction between residential mobility and internal migration is problematic due to considerable ambiguity in what parameters are used to define what constitutes either a short or long distance move (Niedomysl et al., 2017). Assessing if a person has moved at all is further complicated as much of the data available only report a move if that person crosses an administrative boundary. In most contexts these boundaries are of uneven size and shape. This was identified as an issue by Ravenstein (1885), and with reference to contemporary research which relies on these datasets Niedomysl and Fransson (2014, p. 358) argue that '*migration scholars have had little choice but to hope that these problems are not too serious*'.

Thus, many of the studies which consider migration distance tend to use an arbitrary cut-off to define the threshold for short versus long distance moves, or residential mobility versus internal migration. The distance thresholds used are not uniform across studies, and are usually dependent on the definitions available in the dataset being

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used by researchers at the time (White & Mueser, 1988). Our aim is to demonstrate how migration propensity differs depending on the choice of distance threshold used when broken down by a range of population characteristics. This work will provide additional guidance to researchers who are interested in migration distance and looking for justification for choosing a threshold for analysis.

We first review literature from a large field which is focused on migration distance to demonstrate both the breadth of applications and the range of ways in which distance thresholds are defined. We then go on to provide evidence for variations in migration propensity over distance in England and Wales by assessing odds ratios across a range of population attribute categories for 16 distance thresholds reported in microdata from the 2011 Census Sample of Anonymised Records (SARs). Although our work focuses on the situation in England and Wales, our approach will be of relevance in other countries. However, some of the specifics relating to housing tenure, ethnicities, employment, etc. and indeed what may be perceived by people to be a 'short' or a 'long' distance will inevitably have different meanings in different places.

The rest of the paper is structured as follows: Section 2 provides a review of the literature where distance thresholds are used to measure migration; Section 3 provides an overview of data from the SARs and the logistic regression methods used; results are reported in Section 4, and discussion and conclusions offered in Section 5.

2 | REVIEW: DISTANCE AS AN OUTCOME OR AS AN INPUT

Distance features prominently in much of the research on assessing patterns, determinants or outcomes of migration, whether as the outcome of interest or as an input variable into a model designed to measure something else. It can be estimated—with a sizeable body of work evaluating the validity of different approaches (e.g., Niedomysl et al., 2017; Stillwell & Thomas, 2016), inferred based on moves within or across contiguous and non-contiguous administrative boundaries (e.g., Bernard et al., 2016; Foster, 2017) or based on measured distance between addresses (e.g. McCollum et al., 2020; Thomas et al., 2015). The heterogeneity in approach to modelling or defining distance is matched in the variety of thresholds used to distinguish 'short' and 'long' distance moves. Where administrative boundaries are used to determine distance, 'short' distance moves are those within or to contiguous areas, such as local labour market areas (Clark & Withers, 2007; Pelikh & Kulu, 2018), whereas 'long' distance moves are those which cross a boundary. Where actual distance is recorded (or estimated), specific thresholds vary with anything from two (Boyle et al., 2002) to eight or more categories used (Niedomysl & Fransson, 2014).

Across this literature, two themes emerge. The first is concerned with how factors relating to a move vary by distance (Thomas et al., 2019). The second considers the differences in the characteristics of people and households who move across different distances (Finney & Simpson, 2008). These themes emerge because the

selectivity of migration is such that different sub-groups of the population are differently mobile, at different times in their lifecourse, for different reasons, across different distances.

We summarise the extensive work across these themes in two tables outlining how migration is defined/measured, the thresholds used for different distance cut-offs, and how the migration/distance variable is used. In terms of research framework, Table 1 contains literature which treats migration distance as an outcome, whereas Table 2 identifies literature where migration is a model input to aid in the understanding of another outcome. Though not exhaustive, these tables highlight the extent of variation in use of distance thresholds within contemporary research.

Where migration distance is the outcome (Table 1), studies variously cover differences in propensity to move across particular distances according to individual-level and area-level characteristics of movers, make efforts to both improve estimates and models of migration flows and distance moved, or better understand factors shaping migration flows.

Stillwell et al. (2016) compare distance moved (continuous estimates) across 19 countries, finding that settlement patterns dictate that the largest migration distances can be seen in larger countries. At the country-level, (Halás et al., 2016) use migration flow data to define functional regions in the Czech Republic. The authors define three main distance cut-offs (15, 25, and 50 km) which account for the majority of migrant flows. Derivation of these thresholds is theoretically and empirically informed, with the latter based on an evaluation of the frequencies of a move at different distances. Stillwell and Thomas (2016) utilise consumer data within an origin-destination matrix at postcode level to investigate migration distances in England during the mid-2000s and evaluate a method to generate intra-zonal distance estimates.

Niedomysl et al. (2017) similarly evaluate strategies to improve classifications of moves by distance in the absence of individual-level data on actual distance moved. Where aggregate migration flow data exist, establishing a relatively generous fixed distance limit (particularly where administrative regions are large) offers appropriate differentiation between residential mobility (short distance moves) and internal migration (long distance moves). To determine their distance limit, the authors evaluate at what distance threshold proportions of employed movers who changed place of employment levelled off, concluding that a move of over 100 km would denote migration (as opposed to residential mobility) because it would involve a change in the life of the migrants concerned.

Finney and Simpson (2008) assess the extent to which individual-level characteristics differently explain propensity to migrate over distance moved by ethnic group in Britain. Using the Samples of Anonymised Records—a cross-sectional extract from the 2001 Census for England and Wales—the authors distinguish five distance thresholds which are then converted to a continuous variable. Although modelling results find that the characteristics of movers are similar across ethnic groups, there is more differentiation by distance moved. Variables such as age, sex, economic activity, qualifications, tenure and dependent children do not explain

TABLE 1 Studies where migration is used as the outcome of interest

Authors	Migration derivation	Thresholds	Main usage of distance measure
Shuttleworth, Foley, and Champion (2020a)	Six month transition data from northern Irish longitudinal study, aggregated from continuous distance measure at source.	Less than 10 km, 10–50 km, 51 km+	Assessment of multiple moves. Logistic regression of migration distance by individual characteristics.
Clark and Huang (2004)	Change of address reported between waves in British household panel survey, uses centroid to centroid distance of old and new local authority.	0–49 km = short distance; 50 km or over = long distance	To assess sequencing of long distance followed by short distance move.
Finney and Simpson (2008)	One year transition between addresses, straight line distance.	0–4 km; 5–9 km; 10–49 km; 50–199 km; 200+ km	To assess distance migrated by ethnic groups.
Niedomysl and Fransson (2014)	Residential re-registration with distance between small area centroids.	10–19 km; 20–39 km; 40–69 km; 70–109 km; 110–159 km; 160–220 km; 230–329 km; 330+ km	To investigate the relationship between actual migration distances and migration-defining boundaries.
Thomas et al. (2015)	Postcode to postcode straight line distance over a period of up to 3 years.	Distance moved (continuous) as outcome in models.	To assess neighbourhood and city region variations in origins and destinations.
Halás et al. (2016)	Registration in a different municipality, measured as continuous distance.	Various cut-offs used for summaries with consideration of various choices.	Used to define functional regions.
Stillwell et al. (2016)	Modelled from inter-zone distances.	Continuous estimates analysed.	To assess variation in mean migration distance between countries.
Stillwell and Thomas (2016)	Modelled intra-zonal distance.	Continuous estimates analysed.	To evaluate regression-based estimates of intra-zonal moves.
Niedomysl et al. (2017)	Residential re-registration with distance between small area centroids.	<100 km; 100 km +	To investigate the relationship between actual migration distances and moving distances inferred from either population-weighted or area centroids.
Pelikh and Kulu (2018)	Within or between local labour market (LLM) areas.	Long: Between LLMs; short: Within LLMs.	To investigate how education, employment, and family life shape spatial mobility.
Champion and Shuttleworth (2017b)	Patient re-registrations in different region.	Move across a region boundary.	To assess whether rates of long-distance migration are declining.
Champion and Shuttleworth (2017a)	10 year interval small area centroid/postcode straight line distance.	<10 km; 10–49 km; 50–199 km; 200+ km	To report trends in migration propensity over distance thresholds.
McCollum et al. (2020)	Change of address via primary healthcare records/postcode straight line distance.	<10 km; 10–50 km; >50 km	To assess change in characteristics of moves, and rates of change of address/distance moved.

differences between ethnic groups in distanced moved. Rather, the authors suggest these may be better explained by unmeasured spatial differences and connectivity.

More recently, McCollum et al. (2020) used registrations with a doctor, linked to longitudinal census data in Scotland to evaluate the association between different individual-level characteristics and propensity to move, or move across particular distances. Their results chime with much of the extant literature whereby the correlates of move differ by distance (Champion & Shuttleworth, 2017a). McCollum et al. (2020) find that the age-selectivity of migration persists across all distances but younger groups are relatively more mobile, particularly across longer distances; those with higher socio-

economic status are relatively more mobile across greater distances; minority ethnic groups are relatively more mobile than the White Scottish and British group across shorter distances; rural dwellers are more mobile over 10–50 km, whereas urban dwellers are more mobile under 10 km; those living in less deprived areas more mobile over greater distances, whereas those living in more deprived areas are more mobile over short distances.

In terms of migration propensity, there is a growing literature demonstrating that short distance (under 10 km) migration is in decline in the UK. McCollum et al. (2020) demonstrate this for Scotland, whereas Champion and Shuttleworth (2017b) find the same for England and Wales using the Census Longitudinal Study (LS). In

TABLE 2 Studies where migration is an input variable

Authors	Migration derivation	Thresholds	Main usage of distance measure
Niedomysl (2011)	Survey data with distance moved between addresses.	20–35 km; 36–50 km; 51–100 km; 101–150 km; 151+ km	To assess how migration motives change over distance.
Sander and Bell (2016)	Five year transitions.	Moves between area types	To assess inter-cohort differences in the intensity and pattern of migration.
Boyle et al. (2002)	One year transition postcode to postcode straight line distance.	Short: <10 km; Long: >10 km	Investigate relationship between limiting long-term illness and material deprivation of migrants versus non-movers.
Boyle et al. (2003)	One year (UK) and five year (US) transitions between addresses straight line distance.	Short: <50 km; Long: >50 km	To examine effects of long distance migration on women's labour-market status.
Clark and Withers (2007)	Panel data with annual recording of address.	Short: Change of residence within same labour market area Long: Moves between labour market areas	Used to define logistic regression models for short and long term migration.
Bernard et al. (2016)	Change of usual place of residence between two consecutive survey waves; an interval of about a year.	Short: Moves between subdivisions of a large region Long: Moves between large regions	Use administrative units to make comparisons between short and long distance migration in Australia and Great Britain.
Biagi et al. (2011)	Registration data of inter-provincial moves using linear distance in kilometres between the province centroids.	Short: Moves between provinces within the same region Long: Moves between provinces belonging to non-adjacent macro-regions	To define three models – All migration, short distance and long distance migration.
Foster (2017)	Survey respondent report of move since previous year.	Short: Intra-county moves Medium: Intra-state moves Long: Inter-state moves	To define three models investigating the compositional impact of population on migration.
Wilding et al. (2018)	One year transition postcode to postcode straight line distance.	10 km, 20 km, 50 km each used as cut-off	Exploration of health and distance cut-off relationship.
Thomas et al. (2019)	Various: Moves between panel waves (UK - straight line distance between postcodes; Australia – Great-circle distance between two addresses) and Swedish register data (actual distance moved).	Continuous	To assess how migration motives change over distance.
Andersson and Drefahl (2017)	Swedish register data documenting moves from north to South Sweden, and return moves.	Long: North to South Sweden	To assess mortality of long-distance movers within Sweden.

the US there has been a decline in overall migration rates, not just those across shorter distances (Cooke, 2011, 2013).

Migrant decision-making is complex, it is shaped by factors at origin and destination, but also at the individual- and household-level, and this complexity is extremely difficult to capture. Thomas et al. (2015) account for the complexity of migrant decision-making using a multilevel framework, assessing variation in distance moved (based on continuous estimates) for internal migrants in England and Wales reported in commercial survey data. They include microlevel (individual characteristics) influences and origin/destination contextual information simultaneously, finding variations in microlevel distance and a propensity for longer distance moves out of metropolitan cores and into rural and coastal locations. Pelikh and Kulu (2018)

analyse moving ‘trajectories’ rather than a single change of address. In their work, short and long-distance moves are distinguished using Labour Market Areas to define ‘daily activity space’ and event history analysis of the British Household Panel Survey reveals cohort differences in timings of first moves out of the family home, and persistent socio-economic differences in mobility. Similarly, Clark and Huang (2004) note the overlap in decision-making between long and short distance moves, as evidenced by similarities in the patterning of the likelihood of different moves by particular migrant characteristics (e.g., educational attainment, or marital change). Both studies consider that long distance moves are often defined as 50 km or more, though Pelikh and Kulu (2018) opt for moves between Labour Market Areas to define long distance moves.

Short distance moves, often referred to as residential mobility rather than migration, are widely considered not to involve a significant change in the social or economic situation of an individual or household (Pol & Thomas, 2001), or movement away from the community or context of origin (Castro & Rogers, 1979). Understanding how odds of moving across different distances varies according to individual or household characteristics, as presented in some of the studies in Table 1, is one way to differentiate types of move. This may also be indicative of variations in possible outcomes following a migration event, as well as variations in motives for a move. Yet such research is more commonly conducted where migration distance features as an input into models, rather than as the outcome itself. A selection of studies which deal with migration as an input are summarised in Table 2.

Many have urged caution about overly simplistic distinctions between short and long distance moves, made according to theoretical assumptions as to the differences in what motivates either type of move (Clark & Huang, 2004; Clark & Withers, 2007). Others have explicitly tested how motivations for a move vary across distance (Niedomysl, 2011). More recently, Thomas et al. (2019) compared motives for moves across the UK, Sweden and Australia, finding commonalities in the motivations for shorter-distance moves (housing), and longer distance moves (employment), though housing remains important for longer-distance moves in Australia. They find that family-related motives are important and remain important across different migration distances. This is similar to Gillespie and Mulder (2020) who demonstrated that non-resident family constitute an important determinant of migration and should not simply be construed as a by-product of other motives. Yet the point at which the relative importance of housing or family is replaced (if at all) by education or employment is highly context-specific, shaped by the geography of a country and its labour, housing and education markets (Thomas et al., 2019). Although Niedomysl (2011) defined specific (arbitrary) thresholds derived from continuous data, Thomas et al. (2019) used continuous data.

Using measured distance, rather than administrative boundaries, (Boyle et al., 2002) consider the relationship between poor health, material deprivation and migrant status, differentiating between stayers, short-distance (less than 10 km) and long-distance (10 km or more) moves. Wilding et al. (2018) and Andersson and Drefahl (2017) look at the health-migration-distance relationship in more depth. The former evaluates, for working age adults, at what 'long' distance migrants are more likely to be healthier than those who do not migrate, and are healthier than those migrating over shorter distances, using three distance thresholds to define possible 'long' distance moves (10, 20 and 50 km). Andersson and Drefahl (2017) consider the relationship between mortality and long distance moves between the North and South of Sweden. Others have focussed on short distance 'residential mobility' rather than long-distance moves alone (Coulter et al., 2016). In the context of tied-migration Boyle et al. (2003) examine the influence of children on the relationship between long-distance migration (50 km is the cut-off distinguishing short and long distance moves) and labour market status for women. Similar to

studies cited in Table 1, Foster (2017) examined drivers of declining migration within America in terms of the demographic, social and economic characteristics of migrants. Distance is defined according to movement within or between administrative boundaries.

Beyond papers interested in the impact of migration across different distances on individual-level experiences or population composition, migration flows can be estimated for different distances accounting for the influence of socio-economic factors and migration behaviour (Biagi et al., 2011). Elsewhere, migration distance has also been used to evaluate changes in the pattern of migration (Bernard et al., 2016; Sander & Bell, 2016). Common across these studies is the—sometimes explicit—recognition of the importance of context when evaluating differences in distance moved. What constitutes 'long' distance in Sweden will be very different from the distance covered in Australia, even setting aside the varying construction and geographies of labour, housing and education markets. It is then critical to exercise caution in how distance thresholds are used to distinguish short or long-distance moves, particularly when drawing upon existing empirical studies to inform research design.

Distance moved is the outcome of interest in our analysis discussed in the next section. We provide a robust analysis of the relationships between the pertinent characteristics of people who move over a wide range of different distance thresholds, rather than limited groupings or arbitrarily defined distance thresholds or the crossing of an administrative boundary. Investigation of variations in distance moved as an 'explanatory' variable is outside the scope of our analysis. To undertake such work, there would need to be the relevant additional explanatory variables (which might well be different across a range of outcomes) and these are not necessarily available in the data used here.

3 | DATA AND METHODS

We use microdata from the 2011 Census Samples of Anonymised Records (SARs). The SARs are a 5% nationally representative sample of the enumerated England and Wales population and provide a rich multivariate dataset of individual characteristics. The SARs contain a distance moved variable which is calculated using straight line distance between postcode of origin and destination (where a postcode typically identifies a street or group of properties) and is released with the underlying continuous data grouped into distance categories. These distance moved categories are summarised in Figure 1, which reveals that a large proportion of moves occur over relatively short distances, 37% of all moves occur below 3 km, 13% between 3 and 4 km and 21% of moves occur between 5 and 14 km. Cumulatively, half of all moves occur under 5 km and 79% of moves occur at 29 km or less. Migration reported in the SARs is a transition: a person's usual address on the census enumeration date of 27 March 2011 is compared to where they were usually resident 12 months before, and if these are different a migration is recorded. Other, interim moves that a person might make during that 12-month period are not captured in the census data.

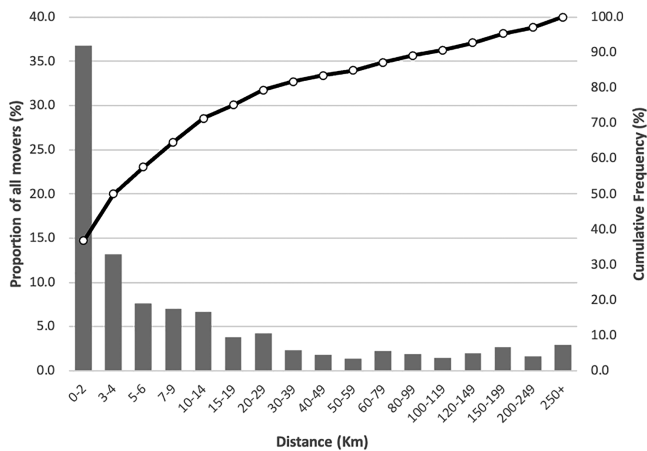


FIGURE 1 Proportion of movers within each distance band reported in the 2011 SARs ($n = 217,399$ movers)

Table 3 presents the SARs variables used in our analysis. Variables identified for use in this study are consistent with previous work and all have been shown to differentiate migration propensity. Grouping of some variable categories has two purposes, first to make results more easily interpretable and in some cases it is done to ensure robust sample sizes.

We define four age groups, (16–29, 30–44, 45–64, 65–74) which broadly relate to different life stages (entering and leaving higher education; marriage, childbearing and raising a family; older working age; retirement) which are often triggers for migration (Bernard et al., 2014) and these groups demonstrate different migration intensities (Kalogirou, 2005). Grouping of ages is necessary to provide sufficient sample sizes when cross-tabulating with other variables. People aged under 16 and over 75 are excluded because of incomplete socioeconomic data for the oldest and youngest age groups. Sex is an important discriminator of migration propensity, especially when coupled with age (Rogers & Castro, 1981).

Marital status reflects key life-transitions which are known triggers of migration (Champion, 2005; Mulder & Wagner, 1993) defined here as single, married, divorced/separated or widowed. Housing tenure is a key differentiator of migration propensity (Boyle, 1993; Hamnett, 1991) and we define four groups, owner occupied, privately rented, socially rented, and people living in communal establishments.

Higher levels of educational attainment are often associated with higher rates of migration (Finney & Simpson, 2008), and we define two groups, people educated to below degree level and people educated to degree level and above. Differentiation between those born in the UK and those born outside the UK is included because of identified differences in propensity between internal migration for those born in a country and foreign born immigrants (Silvestre & Reher, 2014) although we do not have information about length of residence for non-UK born populations which has been found to differentiate the odds of migrating (Darlington-Pollock et al., 2019). Health is measured using a binary definition of Limiting Long Term Illness (LLTI) which combines the responses ‘limited a little’ and ‘limited a lot’ to a single affirmative response. Evidence suggests that, in

general, good health enables migration but poor health motivates moves across shorter distances and is often a trigger for migration of older migrants (Boyle et al., 2002, 2004).

Migration has been found to vary by social class (Catney & Simpson, 2010; Smith & Higley, 2012), which is defined here using the Registrar General's scheme distinguishing between I (Professional); II (Managerial and Technical); IIIN (Skilled non-manual); IIIM (Skilled manual); IV (Partly skilled); V (Unskilled); and a residual ‘unclassified’ (U) category for all those not assigned to a class. Finally, mobility has been found to vary by ethnicity (Finney, 2011; Lomax & Rees, 2015; Raymer et al., 2011) and we differentiate between nine groups which are the most detailed available in the SARs: White British, White Other, Black Caribbean, Black African, Indian, Pakistani, Bangladeshi, Chinese and others.

Binary Logistic Regression is used to model the odds of migrating at different distance thresholds, relative to the reference group (as identified in Table 3) reported as Odds Ratios (ORs). An OR of more than one indicates a greater likelihood of moving relative to the reference group and vice versa. Results presented in the next section are fully adjusted for all variables outlined in Table 3. Variables are stratified by 16 distance thresholds (between ≥ 3 and ≥ 250 km). We are interested in whether and how the relative influence of key determinants of migration differentiate the propensity to migrate shorter or longer distances as the distance threshold increases. For the results presented in Figures 2–7 each distance threshold model should be interpreted separately, with confidence intervals relative to other variables reported for that distance. Where values of Odds Ratios are reported, this is to illustrate the relative influence of the individual variable on propensity to migrate across the different distance thresholds, rather than reflecting an absolute comparison between models.

4 | RESULTS

Results of the binary logistic regression for each group of variables (identified in Table 3) are presented in Figures 2–7. Results are stratified by each distance threshold (≥ 3 and ≥ 250 km). We present the odds ratios and the upper and lower confidence intervals. The value 1 is denoted by a red dashed line in each figure (i.e., the reference category against which odds ratios can be compared). A table of results can be found in the supplementary material.

Figure 2 shows the odds ratios for moves over all distance thresholds by age group and by sex. Females are significantly less likely to move across greater distances than males. This is fairly consistent at around 0.9 at each distance threshold.

Ages 30 to 44 are generally less mobile across greater distances than the reference 16 to 29 group. Conversely, ages 65–74 are consistently more mobile across greater distances than the reference group, with relative differences increasing with increasing distance. The odds ratio for this age group is greater than 1.5 from 20 km. Up until a threshold of 80 km and then again for the 250 km threshold ages 45–64 have slightly higher odds of moving greater distances relative

TABLE 3 Variables used in analysis

Variable (ref = reference group in binary logistic regression)	Frequency	Percent
Age groups		
16 to 29 (ref)	102,257	47
30 to 44	71,496	32.9
45 to 64	35,235	16.2
65 to 74	8411	3.9
	217,399	100
Sex		
Male (ref)	111,087	51.1
Female	106,312	48.9
	217,399	100
Marital status		
Single (ref)	125,597	57.8
Married/re-married	58,516	26.9
Divorced/separated	30,375	14
Widowed	2911	1.3
	217,399	100
Housing tenure		
Owner-occupied (ref)	74,125	34.1
Privately rented	105,363	48.5
Socially rented	29,561	13.6
Communal establishment	8350	3.8
	217,399	100
Educational attainment		
Degree level equivalent or above (ref)	76,199	35.1
Below degree level	141,200	64.9
	217,399	100
Born in UK (stated) or elsewhere		
Born in UK (stated) (ref)	171,147	78.7
Born elsewhere	46,252	21.3
	217,399	100
Limiting long-term illness (LLTI)		
No - LLTI (ref)	194,354	89.4
Yes - LLTI	23,045	10.6
	217,399	100
RGs social class		
Professional (I) (ref)	11,805	5.4
Managerial and technical (II)	55,651	25.6
Skilled non-manual (IIIN)	45,184	20.8
Skilled manual (IIIM)	35,499	16.3
Partly skilled (IV)	24,464	11.3
Unskilled (V)	9365	4.3
Not classified (U)	35,431	16.3
	217,399	100
Ethnic groups		
White British (WBI) (ref)	163,785	75.3
White other (WHO)	20,794	9.6

(Continues)

TABLE 3 (Continued)

Variable (ref = reference group in binary logistic regression)	Frequency	Percent
Black Caribbean (BLC)	2112	1
Black African (BLA)	5352	2.5
Indian (IND)	5787	2.7
Pakistani (PAK)	3095	1.4
Bangladeshi (BAN)	1400	0.6
Chinese (CHI)	2134	1
Mixed and other (MIX)	12,940	6.0
	217,399	100

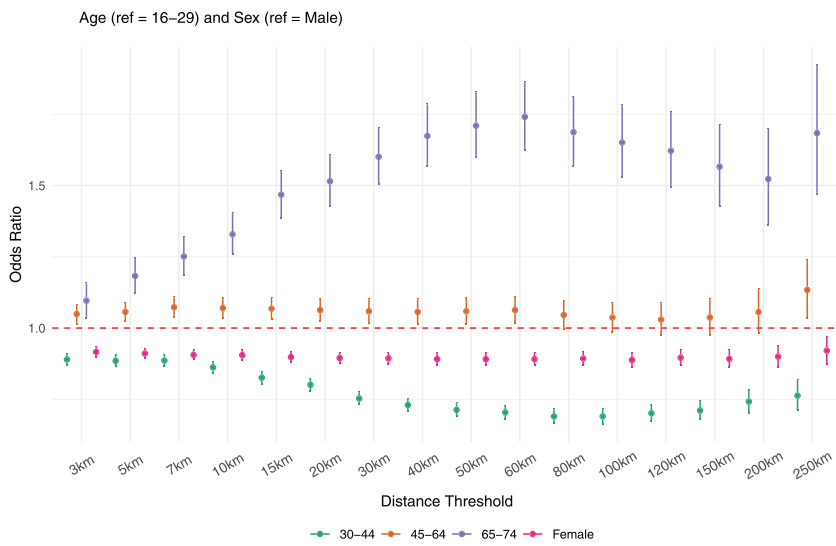


FIGURE 2 Odds ratios of migration over all distance thresholds for age and sex

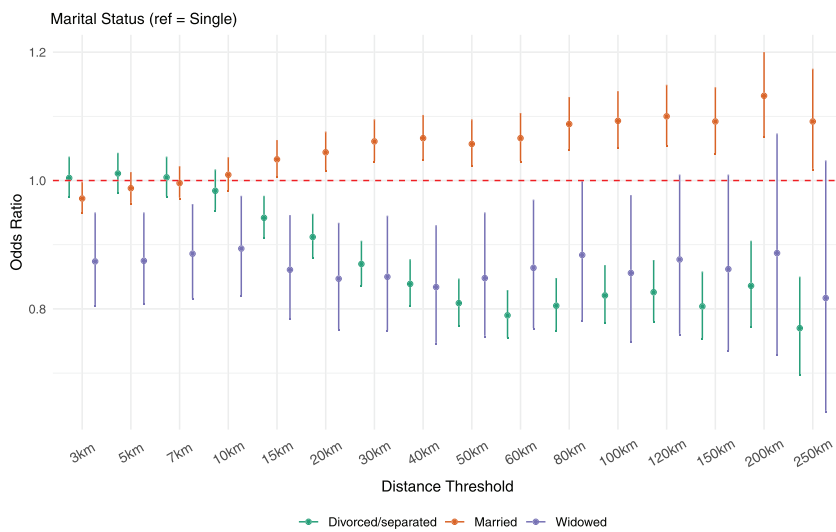


FIGURE 3 Odds ratios of migration over all distance thresholds for marital status

to the 16 to 29 reference group, with the odds ratio ranging between 1.04 and 1.06. For the remaining thresholds, there are no significant difference in distance moved relative to the reference group.

[Correction added on 22 April 2021, after first online publication: the value for Female Frequency '106,312' has been corrected in this version.]

Figure 3 shows that, relative to single people, those who are married are significantly less likely to move 3 km or more, although there is little to differentiate between groups until the 15-km threshold where differences for both married and divorced/separated become significant. A general pattern emerges whereby those who are married

FIGURE 4 (a) Odds ratios of migration over all distance thresholds for communal establishment tenure type. (b) Odds ratios of migration over all distance thresholds for privately rented and socially rented tenure types

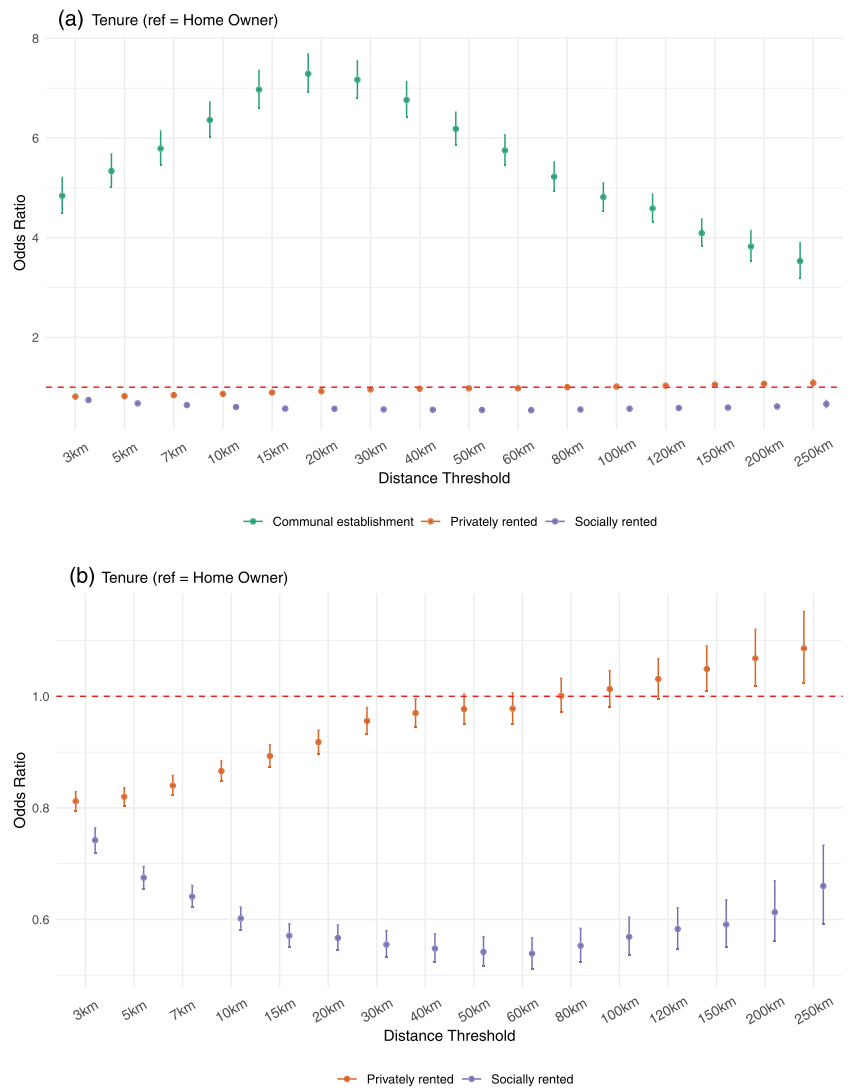
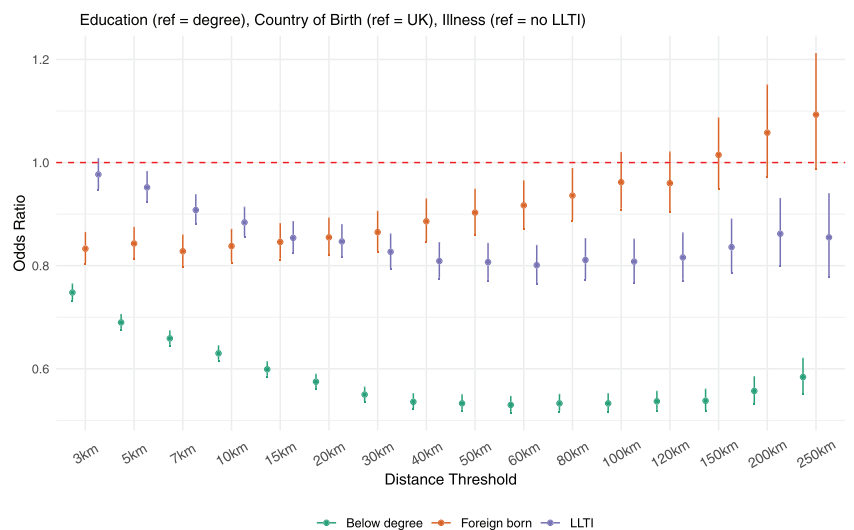


FIGURE 5 Odds ratios of migration over all distance thresholds for education, born overseas and limiting long term illness



are more likely to move at or above the 15-km distance threshold than both single and separated people and the odds ratios increase as distance increases. Conversely, from 15 km those who are divorced/

separated are significantly less likely to move at or above the distance threshold indicating a tendency towards shorter distance moves amongst this group. The general pattern is that the odds ratio falls as

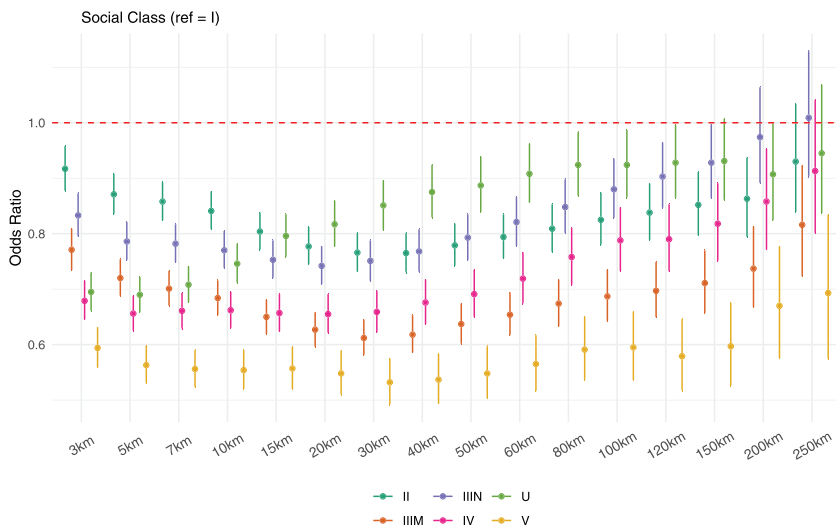


FIGURE 6 Odds ratios of migration over all distance thresholds for social class

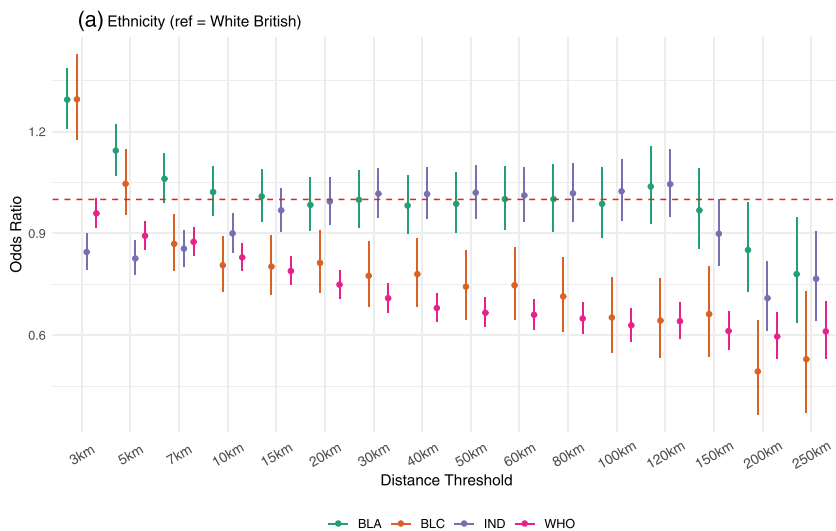
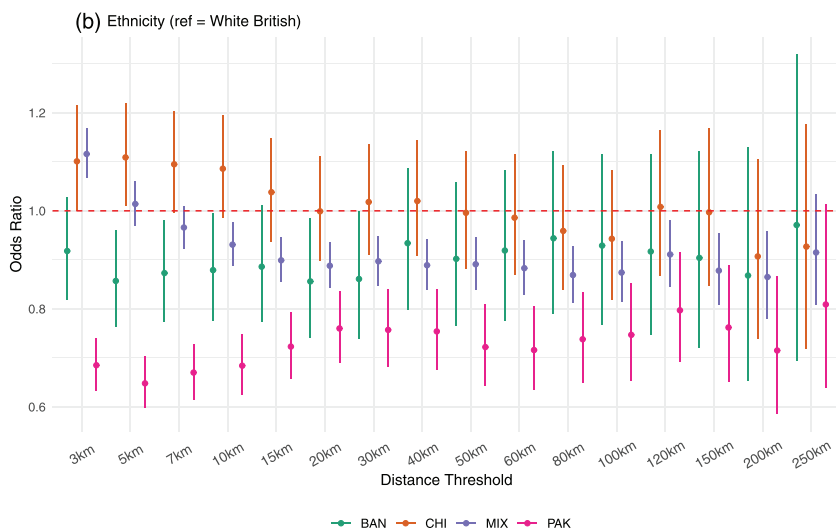


FIGURE 7 (a) Odds ratios of migration over all distance thresholds for four ethnic groups. (b) Odds ratios of migration over all distance thresholds for four ethnic groups



distance increases. The overall effect is a widening of the difference between married and divorced/separated, which stabilises at around 50 km. Being widowed is generally associated with moving

shorter distances, though the differences are not significant at higher distance thresholds, largely due to small sample size (especially at younger ages).

Figure 4a reveals large differences between the mobility of communal establishment residents when compared with home owners, privately rented and socially rented tenants. Communal establishment residents are nearly five times more likely to move than home owners at or above 3 km. The odds ratios continue to rise to the 20 km threshold where communal establishment residents are more than seven times more likely to move at or above the distance threshold than homeowners. There is a steady decline in odds ratios to the 250 + km distance where the ORs are around 3.5.

To better see the results for privately rented and socially rented results, Figure 4b shows these groups with communal establishment residents removed. Some clear patterns emerge when focussing on these groups. Socially rented are consistently less likely to move greater distances, with the odds ratio declining from 0.74 at 3 km and over to 0.54 at 60 km and over. From the 5-km mark differences between these two groups begin to increase as distance increases. Odds ratios increase for privately rented and at the 150-km mark, this group becomes significantly more likely to move over and above the distance threshold than the reference home owner group.

Figure 5 reveals that those educated to below degree level are consistently significantly less likely to move greater distances defined by the distance thresholds, relative to those who are educated to degree level and above. Odds ratios fall from around 0.75 at the 3-km threshold to just above 0.5 from the 15-km threshold where they remain fairly constant at higher distances.

Those with a limiting long-term illness are significantly less likely to move at or above the distance thresholds from the 5-km mark. There is a general pattern of declining odds ratios to the 100-km cut-off. Those who are foreign born are significantly less likely to move than those born in the UK at or above the distance threshold to 80 km. From 100 km, there is no differentiation in distance moved between UK or foreign born groups. Though, as distance increases, the odds ratio does increase for foreign born across all distance thresholds.

Figure 6 demonstrates that all social classes (II to V) are significantly less likely to move at or above the defined thresholds than the Professional (I) social class across most distances. Second most mobile at distance thresholds 3 to 15 km are those in Managerial and Technical roles (II). Consistently, social class V (unskilled) are the least mobile. There is a U shape to the odds ratios for the skilled manual (IIIM) group where relative mobility declines to the 30-km threshold before increasing again. A similar but shallower U shape pattern emerges for group IIIN (skilled non-manual), with declines in odds ratios to 20 km before gradual increase as distance increases. Odds ratios for group IV (partly skilled) are relatively stable until 30 km, after which they increase. As distance increases, the unclassified (U) group odds ratios increase.

Results by ethnic group are split across Figure 7a, b to aid interpretability. The largest variability across all ethnic groups can be seen at the shortest distances reported. The Chinese group are significantly more mobile than the reference White British at and above the 3-, 5-, 7- and 10-km thresholds; the Bangladeshi group are significantly less mobile at the 5- and 7-km thresholds; and the Black African

significantly more mobile at the 3-, 5- and 7-km thresholds. Differences across many groups are not apparent from the 10 km cut-off.

A notable trend is seen for the White Other group, who are consistently less likely to move at or above the distance threshold relative to the reference White British but exhibit declining odds ratios (i.e., are relatively less mobile) as distance increases. At 3 km or more, the Black Caribbean group are significantly more above this threshold relative to the reference group, but odds ratios decline as the distance threshold increases. From 10 km onwards, this group is significantly less likely to move greater distances than the White British reference group.

5 | DISCUSSION AND CONCLUSION

Our results demonstrate the wide differences that exist in the odds of migrating across different distance thresholds when a range of demographic characteristics are assessed. These results show that decisions about cut-offs or definitions of short- and long-distance migration, or indeed residential mobility and migration, need to be considered in the context of the characteristics of interest, or the objectives of the study. By comparing across 16 different distance cut-offs we reveal there are instances where interpretation would differ depending on which threshold were chosen. These include, relative to base/reference categories: (1) variables where differences are significant at some thresholds but not significant at others; (2) variables where odds ratios shift from positive to negative (or vice versa) at a given distance threshold; and (3) variables where the odds ratios are in the same direction at a number of distance thresholds, but the magnitude varies.

There are some clear inflexion points for certain variables where analysis using different cut-offs would conclude different things, so here we are able to offer guidance which should help researchers interested in studying migration distance. Relative to those who are single, those who are divorced or separated become significantly less likely to migrate over greater distances at the 15-km threshold. This is also the distance at which those who are married become significantly more likely to move greater distances. Using our methods, a cut-off of 3, 5, 7 or 10 km would lead to the conclusion that there is no significant difference. In fact, from 15 km onwards the odds of migrating for divorced/separated continue to decline across all thresholds to 60 km and over, whereas it is around the 40-km threshold where the odds of migrating for married people stabilise. One would conclude that the divorced/separated group are more likely to migrate over all distance cut-offs from 15 km onwards and that those who are married are significantly less likely to migrate, but the odds ratios steadily decrease and increase respectively. So while 15 km looks to be a useful threshold in terms of differentiation by marital status, the magnitude of the difference would be interpreted differently depending on the distance cut-off chosen.

Although the odds of migrating for communal establishment residents is significantly higher than for homeowners at all distance thresholds, this rises rapidly from nearly five times more likely at or

over 3 km to a peak of around seven times more likely at 20 km. The 20 km cut-off is insightful for this particular group given the rapid rise in odds ratios from 3 to 20 km. For those in privately rented accommodation, using a cut-off of between 3 and 20 km would lead to conclusions that this group are less likely to migrate than the reference homeowner group, however they become significantly more likely to migrate at thresholds of 120 km and over. For tenure type then, a 20-km threshold might be the most useful for establishing a large and significant difference, but it is useful to know that differences are apparent but less defined at other thresholds.

Analysis of those with a LLTI at the 3-km threshold would lead to conclusions that there is no significant difference compared to those without a LLTI. It is at the 5-km threshold that those with a LLTI become significantly less likely to migrate, and similar conclusions would be drawn for all distance thresholds to 250 km plus. Using our methods, we could conclude that 5 km is an appropriate cut-off for analysing (good or poor) health related migration patterns.

Conclusions about ethnic group migration would be very different depending on which cut-off is chosen for analysis. The Black African group are significantly more likely to migrate than the reference White group at the 3- and 5-km cut-offs, but there is then no significant difference until the 200-km threshold where this group is less likely to migrate. For Black Caribbean, analysis using a 3 km and over cut-off would lead to the conclusion that the group is significantly more likely to migrate, whereas at all cut-offs from 7 km onwards the group is significantly less likely to migrate. Analysis using 3-, 5-, 7- and 10-km cut-offs would reveal that the Indian group are significantly less likely to migrate. However there are then no significant differences until the 200-km threshold. For the Mixed group, analysis using a 3-km cut-off would show that the group is significantly more likely to migrate, whereas a cut-off of 10 km, or any cut-off over that, would show the group is significantly less likely to migrate. There is then no single distance threshold which meaningfully captures all differences across ethnic groups, rather different cut-offs need to be considered depending on which group is being studied.

There are other cases where overall conclusions about the relative mobility of certain groups would be the same across a wide range of distance thresholds, but where conclusions about the size of the difference would vary depending on choice of distance cut-off. This is the case where the 'gradient' of odds ratio steepens or flattens as distance thresholds increase. Odds of migration for those without a degree, relative to those with a degree, are significantly lower across all distance thresholds, although there is a steep gradient of decline in odds-ratio from the 3- to 40-km thresholds. Analysis using a 3 km threshold would result in odds of around 0.75, whereas analysis at 40 km would lead to this being around 0.5. A similar but less steep gradient can be seen for Social Class II, where a 3 km cut-off shows an odds-ratio of around 0.9 but at 20 km this drops to around 0.78. Similar, albeit less sizeable differences, can be observed for the foreign born, where generally the larger the distance threshold chosen between 3 and 80 km, the nearer to 1 is the odds ratio. Though there is very little variation for ages 45 to 64, the odds ratio varies for both age groups 30 to 44 and 65 to 74 relative to the youngest 16–29

reference. For 30 to 44, age groups are generally less mobile than the youngest 16–29 reference, a 10-km cut-off reveals an odds ratio of around 0.8, however this declines at all thresholds to 60 km where it then starts to increase. For ages 65 to 74, the odds ratio increase steadily to 60 km, where they then begin to decline.

Often the decision-making process when choosing distance cut-offs is guided or constrained by the availability of data. This is also true of our study since we are able to assess differences across 16 thresholds but are constrained by the data which can be extracted from the SARs and information is lost in the available categorisations. The only way to get at the full information would be to use a continuous distance measure, something only available in a small number of datasets and used in a limited number of studies (e.g. Halás et al., 2016; Thomas et al., 2015, 2019). The utility of continuous data, and the comparison with imposed distance categories is demonstrated by Niedomysl (2011) who assesses differential migrant characteristics according to distance moved. Using Swedish population register data Niedomysl and Fransson (2014) assess the relationship between 'migration-defining' administrative boundaries (from parish to NUTS1) and actual (continuous) migration distances, both in terms of the volume and characteristics of migrants. The authors demonstrate that conventional approaches which define longer distance migration as those who cross an administrative boundary risk confusing short-distance migrants with long-distance migrants because, overall, most migrants move shorter distances, regardless of the boundary chosen.

This paper has not focused on explaining why there are differences in relative mobility at different distance thresholds. Given the complex and multifaceted drivers of migration, each of the characteristics presented in our results could easily warrant an explanatory paper to itself. For example, in their paper focused on differences in propensity by ethnic group, Darlington-Pollock et al. (2019) point out the intertwined effects of both choice and constraint on migration decisions, suggesting that qualitative research may be better equipped to disentangle these drivers. Similarly the integration of additional information about migration motives from survey data (e.g., as has been done by Thomas et al., 2019, and Shuttleworth, Stevenson, et al., 2020b) would be a fruitful avenue for further research. We hope that by identifying that differences exist across a wide range of thresholds our paper will contribute to ongoing efforts to better understand and quantify variations in migration behaviour and propensity.

In developing the various distance threshold models, our experiences lead us to hypothesise that other variables categorised through different (arbitrary) cut-offs may also produce different results. We defined four age-groups which broadly relate to different life-stages but have found that different groupings lead to different influences of other variables. Geographers are well-acquainted with the 'modifiable areal unit problem'. There seems to be a 'modifiable categorical unit problem' whereby differently specified cut-offs of continuous/ordinal data may generate different conclusions being drawn.

In conclusion, our review has demonstrated that in the broad field of migration research, distance moved is used to answer a wide range

of research questions, but that data availability or decisions about cut-offs result in substantial diversity in how distance is measured or categorised. Our empirical findings demonstrate that migration propensity varies across a number of distance thresholds, which differ in magnitude and direction depending on the migrant attributes being studied. The culmination of both review and analysis demonstrates that decisions about distance thresholds and cut-offs needs to be carefully thought through, and are also very context specific. We hope that this work serves to highlight that the choice of distance threshold should be given prominence in the study design, and that if there is any uncertainty and the data allows, that experiments over different thresholds should be carried out and results compared. Certainly in our analysis we find that using different distance cut-offs would result in different interpretations about relative mobility for different population sub-groups. Our work will be of use to researchers looking for guidance, justification or elements on which to reflect around the use of different migration distance cut-offs.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the UK Data Service. Restrictions apply to the availability of these data, which were used under licence for this study. Data are available at <http://doi.org/10.5255/UKDA-SN-7605-1> with the permission of the UK Data Service.

ORCID

Nik Lomax  <https://orcid.org/0000-0001-9504-7570>

Paul Norman  <https://orcid.org/0000-0002-6211-1625>

Frances Darlington-Pollock  <https://orcid.org/0000-0001-5544-4459>

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APPENDIX A

TABLE A1 Regression results

	3-km threshold			5-km threshold			7-km threshold			10-km threshold						
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig				
(intercept)	3.273	3.130	3.424	***	2.097	2.011	2.187	***	1.576	1.512	1.643	***	1.191	1.143	1.242	***
Sex (male (ref))																
Female	0.916	0.899	0.933	***	0.911	0.895	0.928	***	0.906	0.890	0.923	***	0.905	0.888	0.923	***
Age group (16–29 (ref))																
30–44	0.890	0.870	0.911	***	0.885	0.866	0.906	***	0.886	0.866	0.907	***	0.862	0.841	0.882	***
45–64	1.049	1.016	1.083	**	1.057	1.025	1.090	***	1.073	1.040	1.108	***	1.070	1.036	1.106	***
65–74	1.096	1.037	1.157	**	1.183	1.122	1.247	***	1.251	1.187	1.320	***	1.329	1.259	1.403	***
Ethnic group (White British (ref))																
White other	0.959	0.918	1.002	***	0.893	0.855	0.933	***	0.875	0.837	0.915	***	0.829	0.792	0.869	***
Black Caribbean	1.295	1.178	1.425	***	1.046	0.956	1.145	***	0.869	0.791	0.954	**	0.806	0.730	0.890	***
Black African	1.294	1.211	1.383	***	1.144	1.072	1.220	***	1.061	0.993	1.134	***	1.022	0.954	1.096	***
Indian	0.845	0.795	0.897	***	0.826	0.779	0.877	***	0.855	0.805	0.908	***	0.900	0.846	0.958	***
Pakistani	0.685	0.634	0.739	***	0.648	0.599	0.701	***	0.670	0.617	0.727	***	0.684	0.627	0.746	***
Bangladeshi	0.918	0.821	1.027	***	0.857	0.766	0.959	**	0.873	0.776	0.980	*	0.879	0.777	0.994	*
Chinese	1.101	1.001	1.213	*	1.109	1.011	1.217	*	1.095	0.997	1.201	*	1.086	0.987	1.194	*
Mixed and other	1.116	1.068	1.166	***	1.014	0.972	1.059	***	0.966	0.924	1.008	***	0.931	0.890	0.975	**
Born in UK (stated) or elsewhere (born in UK (ref))																
Born elsewhere	0.833	0.803	0.864	***	0.843	0.813	0.874	***	0.828	0.798	0.859	***	0.838	0.806	0.870	***
Marital status (single (ref))																
Married/re-married	0.972	0.949	0.997	*	0.988	0.964	1.012		0.996	0.972	1.021		1.009	0.983	1.035	
Divorced/separated	1.004	0.974	1.036		1.011	0.981	1.042		1.005	0.974	1.036		0.984	0.953	1.016	
Widowed	0.874	0.805	0.949	**	0.875	0.807	0.949	**	0.886	0.815	0.962	**	0.894	0.820	0.975	*
RGs social class (I (ref))																
II	0.917	0.877	0.958	***	0.871	0.835	0.908	***	0.858	0.824	0.893	***	0.841	0.808	0.876	***
IIIN	0.833	0.795	0.873	***	0.786	0.752	0.821	***	0.782	0.749	0.817	***	0.770	0.738	0.805	***
IIIM	0.771	0.734	0.809	***	0.720	0.688	0.754	***	0.701	0.670	0.733	***	0.684	0.653	0.716	***
IV	0.679	0.646	0.715	***	0.656	0.625	0.688	***	0.661	0.629	0.693	***	0.662	0.630	0.695	***
V	0.594	0.559	0.631	***	0.563	0.531	0.598	***	0.556	0.523	0.590	***	0.554	0.520	0.590	***
U	0.695	0.661	0.730	***	0.690	0.658	0.722	***	0.708	0.676	0.741	***	0.746	0.711	0.782	***
Educational attainment (degree level equivalent or above (ref))																
Below degree	0.748	0.732	0.764	***	0.690	0.676	0.705	***	0.659	0.645	0.673	***	0.630	0.616	0.644	***

(Continues)

TABLE A1 (Continued)

	3-km threshold			5-km threshold			7-km threshold			10-km threshold					
	OR	LCI	UCI	Sig	OR	LCI	UCI	OR	LCI	UCI	OR	LCI	UCI	Sig	
Housing tenure (owner-occupied (ref))															
Privately rented	0.812	0.795	0.829	***	0.820	0.804	0.836	***	0.840	0.824	0.858	0.866	0.848	0.884	***
Socially rented	0.742	0.720	0.764	***	0.675	0.655	0.695	***	0.641	0.622	0.661	0.602	0.582	0.622	***
Communal establishment	4.842	4.504	5.210	***	5.337	5.017	5.683	***	5.790	5.464	6.139	6.362	6.019	6.727	***
Limiting long-term illness (no LLTI (ref))															
LLTI	0.977	0.947	1.007		0.952	0.924	0.982	**	0.908	0.880	0.937	0.884	0.855	0.913	***
15-km threshold															
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	OR	LCI	UCI	Sig
(intercept)	0.902	0.864	0.941	***	0.761	0.728	0.795	***	0.603	0.576	0.631	0.518	0.494	0.543	***
Sex (male (ref))															
Female	0.898	0.880	0.916	***	0.895	0.877	0.914	***	0.894	0.874	0.914	0.891	0.870	0.912	***
Age group (16–29 (ref))															
30–44	0.826	0.805	0.847	***	0.801	0.779	0.822	***	0.753	0.732	0.775	0.730	0.708	0.752	***
45–64	1.068	1.031	1.106	***	1.063	1.025	1.103	**	1.059	1.018	1.101	1.057	1.014	1.101	**
65–74	1.468	1.386	1.553	***	1.515	1.428	1.607	***	1.601	1.504	1.703	1.674	1.570	1.785	***
Ethnic group (White British (ref))															
White other	0.789	0.751	0.829	***	0.749	0.710	0.789	***	0.709	0.669	0.750	0.680	0.641	0.722	***
Black Caribbean	0.802	0.720	0.892	***	0.813	0.726	0.908	***	0.775	0.685	0.874	0.780	0.686	0.884	***
Black African	1.009	0.937	1.086		0.984	0.910	1.063		0.999	0.919	1.084	0.982	0.901	1.070	
Indian	0.968	0.907	1.032		0.994	0.929	1.062		1.017	0.947	1.091	1.016	0.945	1.093	
Pakistani	0.723	0.659	0.792	***	0.760	0.691	0.835	***	0.757	0.683	0.838	0.754	0.677	0.838	***
Bangladeshi	0.886	0.776	1.010		0.856	0.743	0.983	*	0.861	0.740	0.998	0.934	0.800	1.085	
Chinese	1.038	0.939	1.147		0.999	0.899	1.109		1.018	0.911	1.135	1.020	0.909	1.142	
Mixed and other	0.899	0.857	0.944	***	0.888	0.844	0.934	***	0.897	0.849	0.946	0.889	0.840	0.940	***
Born in UK (stated) or elsewhere (born in UK (ref))															
Born elsewhere	0.846	0.812	0.881	***	0.855	0.820	0.892	***	0.865	0.827	0.905	0.886	0.846	0.929	***
Marital status (single (ref))															
Married/re-married	1.033	1.005	1.062	*	1.044	1.015	1.075	**	1.061	1.029	1.094	1.066	1.032	1.101	***
Divorced/separated	0.942	0.910	0.975	***	0.912	0.879	0.947	***	0.870	0.835	0.905	0.839	0.804	0.876	***
Widowed	0.861	0.784	0.945	**	0.847	0.767	0.933	***	0.850	0.765	0.944	0.834	0.746	0.929	**
RGs social class I (ref))															
II	0.804	0.771	0.838	***	0.777	0.745	0.812	***	0.766	0.732	0.801	0.765	0.730	0.801	***

TABLE A1 (Continued)

	15-km threshold			20-km threshold			30-km threshold			40-km threshold						
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig
IIIN	0.753	0.720	0.788	***	0.742	0.709	0.777	***	0.751	0.715	0.788	***	0.768	0.731	0.808	***
IIIM	0.650	0.619	0.681	***	0.627	0.596	0.658	***	0.612	0.581	0.645	***	0.618	0.586	0.653	***
IV	0.657	0.624	0.691	***	0.655	0.621	0.691	***	0.659	0.622	0.697	***	0.676	0.637	0.717	***
V	0.557	0.520	0.596	***	0.548	0.510	0.589	***	0.532	0.492	0.575	***	0.537	0.494	0.583	***
U	0.796	0.758	0.835	***	0.817	0.777	0.859	***	0.851	0.807	0.896	***	0.875	0.829	0.924	***
Educational attainment (degree level equivalent or above (ref))																
Below degree	0.599	0.585	0.613	***	0.575	0.561	0.589	***	0.550	0.536	0.564	***	0.536	0.522	0.551	***
Housing tenure (owner-occupied (ref))																
Privately rented	0.893	0.873	0.913	***	0.918	0.897	0.939	***	0.956	0.933	0.980	***	0.970	0.945	0.995	*
Socially rented	0.571	0.550	0.592	***	0.567	0.545	0.590	***	0.555	0.532	0.580	***	0.548	0.523	0.574	***
Communal establishment	6.972	6.607	7.358	***	7.290	6.914	7.688	***	7.170	6.805	7.555	***	6.765	6.422	7.128	***
Limiting long-term illness (no LLTI (ref))																
LLTI	0.854	0.824	0.885	***	0.847	0.816	0.879	***	0.827	0.794	0.861	***	0.809	0.775	0.844	***
50-km threshold																
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig
(intercept)	0.450	0.428	0.473	***	0.395	0.376	0.416	***	0.312	0.295	0.329	***	0.252	0.238	0.267	***
Sex (male (ref))																
Female	0.891	0.869	0.913	***	0.891	0.869	0.914	***	0.893	0.869	0.917	***	0.888	0.863	0.914	***
Age group (16–29 (ref))																
30–44	0.713	0.690	0.736	***	0.704	0.681	0.728	***	0.690	0.666	0.715	***	0.690	0.664	0.716	***
45–64	1.059	1.015	1.106	**	1.063	1.017	1.111	**	1.046	0.998	1.097	**	1.037	0.986	1.090	***
65–74	1.710	1.600	1.827	***	1.741	1.626	1.863	***	1.687	1.569	1.812	***	1.651	1.529	1.782	***
Ethnic group (White British (ref))																
White other	0.666	0.626	0.709	***	0.660	0.619	0.704	***	0.649	0.605	0.696	***	0.629	0.584	0.678	***
Black Caribbean	0.743	0.649	0.848	***	0.747	0.649	0.856	***	0.714	0.613	0.827	***	0.652	0.550	0.767	***
Black African	0.987	0.903	1.079	***	1.001	0.913	1.096	***	1.001	0.908	1.102	***	0.987	0.890	1.093	***
Indian	1.020	0.945	1.099	***	1.012	0.935	1.093	***	1.018	0.937	1.105	***	1.024	0.938	1.116	***
Pakistani	0.722	0.644	0.807	***	0.716	0.636	0.804	***	0.738	0.651	0.833	***	0.747	0.654	0.850	***
Bangladeshi	0.902	0.767	1.057	***	0.919	0.778	1.081	***	0.944	0.792	1.120	***	0.929	0.769	1.114	***
Chinese	0.996	0.884	1.120	***	0.986	0.872	1.113	***	0.959	0.840	1.091	***	0.943	0.820	1.082	***
Mixed and other	0.891	0.840	0.945	***	0.883	0.830	0.938	***	0.869	0.814	0.927	***	0.874	0.815	0.936	***
Born in UK (stated) or elsewhere (born in UK (ref))																

(Continues)

TABLE A1 (Continued)

	50-km threshold			60-km threshold			80-km threshold			100-km threshold					
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig			
Born elsewhere	0.903	0.860	0.948	***	0.917	0.871	0.964	***	0.936	0.887	0.988	*	0.962	0.909	1.019
Marital status (single (ref))															
Married/re-married	1.057	1.022	1.094	**	1.066	1.029	1.104	***	1.088	1.048	1.129	***	1.093	1.050	1.138
Divorced/separated	0.809	0.773	0.846	***	0.790	0.754	0.828	***	0.805	0.765	0.847	***	0.821	0.778	0.867
Widowed	0.848	0.757	0.949	**	0.864	0.769	0.969	*	0.884	0.781	0.998	*	0.856	0.748	0.976
RGs social class (I (ref))															
II	0.779	0.742	0.818	***	0.794	0.756	0.835	***	0.809	0.767	0.853	***	0.825	0.780	0.874
IIIN	0.793	0.752	0.835	***	0.821	0.778	0.866	***	0.848	0.801	0.898	***	0.880	0.828	0.935
IIIM	0.637	0.602	0.674	***	0.654	0.617	0.694	***	0.674	0.633	0.717	***	0.687	0.643	0.735
IV	0.691	0.650	0.735	***	0.719	0.674	0.766	***	0.758	0.708	0.810	***	0.788	0.733	0.847
V	0.548	0.503	0.597	***	0.565	0.516	0.617	***	0.591	0.537	0.650	***	0.595	0.536	0.659
U	0.887	0.839	0.939	***	0.908	0.857	0.962	**	0.924	0.868	0.983	*	0.924	0.865	0.987
Educational attainment (degree level equivalent or above (ref))															
Below degree	0.533	0.519	0.549	***	0.530	0.515	0.546	***	0.533	0.517	0.550	***	0.533	0.516	0.551
Housing tenure (owner-occupied (ref))															
Privately rented	0.977	0.951	1.004		0.978	0.951	1.006		1.001	0.971	1.032		1.013	0.981	1.046
Socially rented	0.542	0.516	0.569	***	0.539	0.511	0.567	***	0.553	0.523	0.584	***	0.569	0.536	0.604
Communal establishment	6.185	5.869	6.518	***	5.752	5.454	6.066	***	5.224	4.945	5.519	***	4.815	4.545	5.100
Limiting long-term illness (no LLTI (ref))															
LLTI	0.807	0.771	0.843	***	0.801	0.765	0.839	***	0.811	0.772	0.852	***	0.808	0.766	0.851
120-km threshold															
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI
(intercept)	0.204	0.191	0.217	***	0.152	0.142	0.163	***	0.087	0.080	0.095	***	0.048	0.043	0.054
Sex (male (ref))															
Female	0.896	0.869	0.924	***	0.892	0.862	0.923	***	0.900	0.863	0.938	***	0.921	0.875	0.970
Age group (16-29 (ref))															
30-44	0.701	0.673	0.730	***	0.711	0.680	0.744	***	0.742	0.702	0.784	***	0.763	0.713	0.817
45-64	1.030	0.976	1.087		1.037	0.976	1.101		1.056	0.982	1.137		1.134	1.036	1.240
65-74	1.622	1.495	1.759	***	1.566	1.429	1.714	***	1.523	1.362	1.700	***	1.684	1.472	1.923
Ethnic group (White British (ref))															
White other	0.641	0.592	0.694	***	0.612	0.560	0.669	***	0.596	0.534	0.665	***	0.611	0.533	0.698
Black Caribbean	0.643	0.535	0.766	***	0.662	0.540	0.802	***	0.493	0.369	0.643	***	0.529	0.372	0.727

TABLE A1 (Continued)

	120-km threshold			150-km threshold			200-km threshold			250-km threshold						
	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig	OR	LCI	UCI	Sig
Black African	1.038	0.931	1.155		0.968	0.857	1.091		0.851	0.729	0.990	*	0.780	0.640	0.944	*
Indian	1.045	0.952	1.145		0.899	0.808	0.998	*	0.709	0.616	0.815	***	0.766	0.644	0.905	**
Pakistani	0.797	0.694	0.913	**	0.762	0.652	0.887	***	0.715	0.587	0.864	***	0.809	0.640	1.011	
Bangladeshi	0.917	0.748	1.114		0.904	0.722	1.120		0.868	0.655	1.128		0.971	0.695	1.318	
Chinese	1.008	0.870	1.162		0.997	0.848	1.166		0.907	0.740	1.103		0.927	0.721	1.175	
Mixed and other	0.911	0.846	0.980	*	0.878	0.809	0.952	**	0.865	0.782	0.956	**	0.915	0.809	1.033	
Born in UK (stated) or elsewhere (born in UK (ref))																
Born elsewhere	0.960	0.904	1.020		1.015	0.949	1.086		1.058	0.972	1.150		1.093	0.987	1.211	
Marital status (single (ref))																
Married/re-married	1.100	1.054	1.148	***	1.092	1.041	1.144	***	1.132	1.068	1.199	***	1.092	1.017	1.173	*
Divorced/separated	0.826	0.780	0.875	***	0.804	0.753	0.857	***	0.836	0.772	0.905	***	0.770	0.697	0.849	***
Widowed	0.877	0.760	1.008		0.862	0.734	1.008		0.887	0.728	1.072		0.817	0.640	1.030	
RGs social class I (ref))																
II	0.838	0.789	0.890	***	0.852	0.797	0.911	***	0.863	0.794	0.937	***	0.930	0.839	1.034	
IIIN	0.903	0.847	0.964	**	0.928	0.864	0.997	*	0.974	0.891	1.064		1.009	0.903	1.129	
IIIM	0.697	0.649	0.749	***	0.711	0.657	0.770	***	0.737	0.668	0.813	***	0.816	0.723	0.923	**
IV	0.790	0.732	0.853	***	0.818	0.751	0.891	***	0.858	0.772	0.953	**	0.913	0.801	1.041	
V	0.579	0.517	0.646	***	0.597	0.526	0.675	***	0.670	0.576	0.777	***	0.693	0.574	0.834	***
U	0.928	0.865	0.996	*	0.931	0.861	1.007		0.907	0.824	1.000	*	0.945	0.837	1.068	
Educational attainment (degree level equivalent or above (ref))																
Below degree	0.537	0.519	0.556	***	0.538	0.518	0.560	***	0.557	0.531	0.584	***	0.584	0.551	0.620	***
Housing tenure (owner-occupied (ref))																
Privately rented	1.031	0.996	1.067		1.049	1.010	1.090	*	1.068	1.019	1.120	**	1.086	1.024	1.152	**
Socially rented	0.583	0.547	0.621	***	0.591	0.550	0.635	***	0.613	0.561	0.669	***	0.660	0.592	0.733	***
Communal establishment	4.588	4.318	4.875	***	4.092	3.826	4.374	***	3.824	3.525	4.147	***	3.529	3.190	3.900	***
Limiting long-term illness (no LLTI (ref))																
LLTI	0.816	0.771	0.863	***	0.836	0.785	0.890	***	0.862	0.799	0.930	***	0.855	0.778	0.939	**

Note: RGs Social Class—I Professional, II Managerial and Technical, IIIN Skilled non-manual, IIIM Skilled manual, IV Partly skilled, V Unskilled, U Not classified. ****p* < 0.001. ***p* < 0.01. **p* < 0.05, *p* < 0.1.