Family trajectories and health of Pakistanis and their descendants in the United Kingdom and Norway

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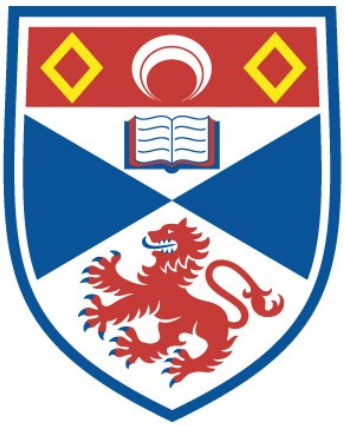
Joseph Harrison

A thesis submitted for the degree of PhD
at the
University of St Andrews



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Research data/Digital outputs access statement

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Table of contents

List of tables

List of figures

Abstract

Immigrant and minority incorporation and assimilation are highly relevant for policymakers, academics, and wider society. Previous family and health research has shown huge variation between minority groups. However, most studies have compared only in one context. This research investigates Pakistani immigrants and their descendants in the United Kingdom and Norway. The study contains three empirical chapters, on family formation trajectories, cancer incidence and mortality and all-cause mortality. It applies longitudinal methods, to individual level administrative and survey data to identify differences between Pakistanis and natives, changes between the immigrant generation and their descendants, and differences between a group of the same origin in the UK and Norway.

The results show distinct similarities between UK and Norway in cancer incidence and mortality. Similarities are also observed in family formation, although second generation immigrants in Norway are more like natives compared to the UK where they have maintained similar trajectories to the immigrant generation. For mortality Pakistani migrants in Norway have worse mortality than natives, something which is sustained to the second generation. In England and Wales this is not the case, Pakistani immigrants experience a mortality advantage compared to natives, and their descendants have similar mortality risks. However, when comparing Pakistanis in Norway to Pakistanis in England and Wales, those in Norway have lower risk of mortality. This all indicates that the pathways to assimilation can vary across life course domains and are influenced by the destination context that immigrant groups experience.

1. Introduction

Research on immigrant incorporation has been highly successful in comparing groups of migrants and their descendants in one country. This has been explored across various aspects of the life course including (but not limited to), the transition to adulthood and leaving the parental home (Zorlu and Mulder, 2010; Ferrari and Pailhé, 2017; McAvay and Pailhé, 2022), living arrangements (de Valk and Billari, 2007; Kuhnt and Krapf, 2020), fertility and childbearing patterns (Milewski, 2007, 2010b; Dubuc, 2012; Mussino and Strozza, 2012; Kulu and Hannemann, 2016; Andersson, Persson and Obućina, 2017), union dynamics (Andersson, Obućina and Scott, 2015; Hannemann and Kulu, 2015; Pailhé, 2015; Hannemann *et al.*, 2020; Mikolai and Kulu, 2022c), morbidity and health (Hemminki and Li, 2002a; Evandrou *et al.*, 2016; Hjerkind *et al.*, 2017, 2020; Cézard *et al.*, 2022), socioeconomic outcomes (Li and Heath, 2008, 2020; Khoudja and Platt, 2018), internal migration (Fischer and Malmberg, 1997; Catney and Finney, 2016), and mortality (Wallace and Kulu, 2015; Syse *et al.*, 2016; Bhopal *et al.*, 2018; Wallace and Wilson, 2019; Wallace, 2022). However, there are very few studies which successfully apply a cross national perspective to compare one origin group in multiple destinations; the main examples are works on the Turkish diaspora in Europe which utilise either population registers to study health (Spallek *et al.*, 2012) or The Integration of the European Second-generation (TIES) survey to study education and union formation (Huschek, Liefbroer and de Valk, 2010; Baysu, Alanya and de Valk, 2018). To date the only comparative work on the Pakistani diaspora is on the similarities of hiring disadvantage and discrimination in the UK and Norwegian labour market (Larsen and Di Stasio, 2021).

The objective of this thesis is to investigate differences in the life course outcomes and experiences of Pakistani immigrants and their descendants compared the majority population in varying contexts. More specifically, it assesses the differences in family formation trajectories and health outcomes of Pakistani immigrants, their descendants, and the majority population in two countries, the United Kingdom (in this thesis sometimes England and Wales due to data availability) and Norway. Both these countries are home to large numbers of foreign born individuals, approximately one sixth of the population are born overseas, and both have relatively large proportions of Pakistani immigrants and descendants (Office for National Statistics, 2020, 2022a;

Statistics Norway, 2023b). The focus on Pakistanis specifically provides a novel opportunity to compare an origin group in two different destinations, where they have been surrounded by similar high income country standards of living but in distinctly different welfare state contexts. This enables us to interrogate differences (and inequalities) in the experiences of immigrant-origin populations in nuanced ways that are attentive to the specificities of time and place. Thereby, we can revisit, theoretically and empirically, understandings of immigrant assimilation and integration.

The study of immigrants' and their descendants' family formation trajectories, health and well-being has gained significant academic and societal attention. As global migration continues to rise and migration and migrant integration remain high on the political agenda across the world (de Haas, Castles and Miller, 2019). Identifying the extent to which immigrants' behaviours and life course outcomes differ from the majority population offers key insight into the success of migrant incorporation policies in the destination country. Classical assimilation theory suggests that divergences can be a symptom of persistent disadvantage and a failure to access mainstream society (Portes and Zhou, 1993; Alba and Nee, 1997; Heath and Schneider, 2021). However, for some domains of the life course such as health and mortality- where immigrants often have an advantage despite socioeconomic disparities (Razum, 2008; Aldridge *et al.*, 2018)- assimilation to 'native like' mortality outcomes could be considered a negative outcome (Antecol and Bedard, 2006).

This work will study three life course domains: first, family formation trajectories incorporating union formation and fertility, second, health and morbidity, through the lens of cancer incidence and cancer mortality, and last, all-cause mortality differentials. In doing so it contributes to the field an in-depth study of the Pakistani group, offering a comparative perspective on how contextual factors in the destination, such as the welfare state differences, are related to intergenerational assimilation of behaviours and inequalities between Pakistani immigrants, their descendants and natives in both the UK and Norway.

The novelties of this work are as follows. First, its consideration of one immigrant group in two different countries, something seldom done and even less commonly done on Pakistanis. Second, it uses methods which focus on both the immigrant generation

and their descendants, which will enable identification of changes between them and improve understanding of the assimilation trajectories of the Pakistani population in the United Kingdom and Norway. Third, since few previous studies have taken into consideration the effects of individual socioeconomic and sociodemographic factors, this study uses large scale individual level data available from both surveys and administrative datasets. Last, this thesis applies novel longitudinal methods, including multichannel sequence analysis and event history analysis, which offer much novelty in life course research.

1.1. Research questions

This thesis is comprised of three quantitative studies which each use novel longitudinal methods on individual level data to address specific research questions.

Chapter 1 identifies differences in family typologies between Pakistani immigrants, their descendants, and the majority population in the United Kingdom. It develops an understanding of the different trajectories of the ancestral native White British population and that of the Pakistani minority. It answers the following questions;

1 How do the family trajectories differ between the ancestral native population and that of the Pakistani minority?
2 How similar are the trajectories between Pakistani immigrants and their descendants?
3 How have the trajectories of Pakistanis changed by birth cohort? Lastly, how does an individual's education level shape family trajectories of the Pakistani population?

Chapter 2 investigates cancer incidence and mortality in Pakistani and Bangladeshi immigrants and their descendants in England and Wales. It quantifies the differences in the risk of cancer incidence and subsequent cancer mortality between ancestral natives, the Pakistani born, Bangladeshi born and their descendants in England and Wales. This study also addresses three research questions, which are;

1 How does cancer onset differ between White British, Pakistani and Bangladeshi immigrants, and their descendants?

2 Following onset is there a difference in survival between White British, Pakistani and Bangladeshi immigrants, and their descendants?
3 Can any differences in onset or survival be explained by socio-economic factors?

The final empirical chapter applies a comparative perspective to the migrant mortality advantage in two contexts, England and Wales and Norway. The study contributes to the existing body of literature on migrant mortality, and furthers knowledge about the transmission of this advantage, or not, to the descendants of immigrants. It offers great novelty by directly comparing Pakistani immigrants in one destination context to Pakistani immigrants in the other. The research questions for this study are as follows;

1 How does migrant mortality compare across the two countries?
2 How does the mortality of the descendants of migrants in both countries compare?
3 How does the mortality of immigrants, descendants, and Pakistani immigrants in Norway compare to the mortality of the same groups in England and Wales?

1.2. Structure

The next section provides an overview of the theoretical background that underpins the processes that are central to this thesis. This is followed by an overview of the migration context of Pakistanis in the UK and Norway and the data and methods that will be used to address the research questions.

What follows are then three separate studies which highlight various aspects of the life course. They share the common thread of using longitudinal methods to shed light on differences between Pakistani immigrants, their descendants, and the majority population, firstly in the UK (England and Wales) context, followed by a comparative study of England and Wales and Norway. Through this we can infer the extent of assimilation of demographic outcomes. First, a published research article in Demographic Research titled **"Union formation and fertility amongst immigrants from Pakistan and their descendants in the United Kingdom: A multichannel sequence analysis"** (Harrison, Keenan, *et al.*, 2023). Second, a manuscript published in BMC Public Health called **"All-cancer incidence and mortality in Pakistanis,**

Bangladeshis and their descendants in England and Wales." (Harrison *et al.*, 2024) Last a completed manuscript, submitted to Demography, which is a comparison of the migrant mortality advantage in Norway and England and Wales, including an emphasis on comparing the Pakistani immigrant population across the two contexts. This paper is provisionally titled **"Migrant mortality advantage in two different welfare contexts: A comparison of England & Wales and Norway."**

Following these three empirical chapters, is a critical discussion section. Here the results of the previous chapters will be overviewed and discussed in a holistic manner. This chapter places the results of the UK based studies from chapter one and two in a comparative perspective with prior research from Norway and links all the results to the wider theoretical discourse upon which they rest.

1.3. Authorship contributions

All three empirical chapters are written for peer-review journal publication. As such they are co-authored with my supervisor team and for Chapter 6 an additional external collaborator. The details of the contributions for each paper can be found in Table 1.1.

Table 1.1 - Authorship contributions for empirical chapters

Contribution	Chapter 4	Chapter 5	Chapter 6
Conception	JH, HK	JH, HK	JH, HK, ØK
Research design	JH, HK	JH, HK, KK, FS	JH, HK, KK, FS ØK
Data management	JH	JH	JH
Analysis	JH	JH	JH
First draft of text	JH	JH	JH
Editing	JH, HK, KK, FS	JH, HK, KK, FS	JH, HK, KK, FS
Revisions for publication	JH, HK, KK, FS	JH, HK, KK, FS	N/A*

Notes:
JH: Joseph Harrison, HK: Hill Kulu, KK: Katherine Keenan, FS: Frank Sullivan, ØK: Øystein Kravdal
*Decision yet to be made by journal

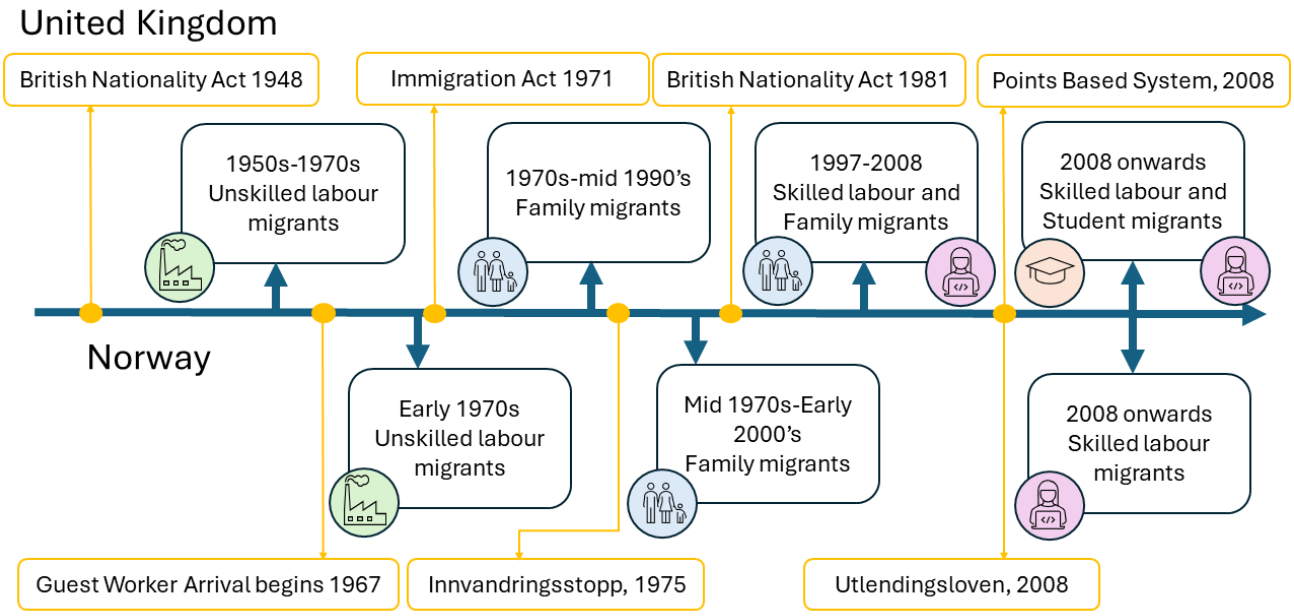
2. Background and Context

The contribution of this body of work sheds light on integration and assimilation pathways of Pakistani immigrants and their descendants. Thus, it is pertinent to provide context on the migration and experiences of Pakistanis to the UK and Norway. Moreover, the focus of the thesis is on specific domains of the life course, namely family formation, health, and mortality. These domains have their own theories that underpin different outcomes for migrants compared to natives. Whilst these conceptual bases are explored in the relevant empirical chapters, this section provides an outline of the main theories that underpin this thesis after the migration context of Pakistanis is described.

2.1. Pakistani context

A timeline of the migration history can be seen in Figure 2.1 below, highlighting the similar timelines and selection method that has dominated migration flows from Pakistan to the UK and Norway.

Figure 2.1 - Timelines showing historical migration from Pakistan into United Kingdom and Norway



Source: Adapted from (Brochmann and Kjeldstadli, 2008; Luthra and Platt, 2017)
Translations: Innvandringsstopp = Immigration Stop; Utlendingsloven = Immigration Act

2.1.1. Pakistani migration to the UK

The Pakistani community in the United Kingdom is the largest diaspora of Pakistani people in Europe. From the 2021 England and Wales census, the ethnic Pakistani group, which includes both migrants and descendants, totals well over one and a half million (Office for National Statistics, 2022a). Of these slightly fewer than half are immigrants, born in Pakistan (Office for National Statistics, 2022b). The migration history stems from labour shortages in the UK suffered post-WWII: migration from former colonies became actively encouraged to fill these labour gaps and rebuild the country. Pakistan was one of these migrant sending countries. The first wave of these immigrants arriving in the 1950's and early 1960's shared relatively homogenous characteristics; primarily men originating from two regions of Pakistan, Punjab and Kashmir (Shaw, 2000). They had few skills or qualifications, limited English language proficiency, and arrived unaccompanied. Their geographic placement centred on towns and cities in the midlands and north where they worked in textiles, manufacturing and steel industries (Price, 2014). Initially migration of these men was seen as a temporary measure for the UK government. The men sent remittances back to Pakistan with the intention of returning to their families at some point (Dahya, 1972). Ultimately, the return migration never materialised, and they remained in England. Following this permanency, kinship networks developed in more depth and the UK. The male migrants were then joined by women and children coming to join their husbands and fathers. Additionally, more people from the same communities in Pakistan followed, they saw the prosperity of migration and the possibilities offered overseas, thus the communities continued to grow.

Thereafter immigration policy shifted to quell new arrivals. The 1962 Commonwealth Immigrants Act created higher barriers to entry and removed automatic immigration rights to Commonwealth citizens. This meant that family reunification became the main source of Pakistani migrants as opposed to labour migrants (Vertovec, 2007). Migration was further fuelled by the independence movement of East Pakistan and the birth of what is now Bangladesh. This created an environment of civil unrest which was a push factor for many to settle permanently and bring spouses and family over (Peach, 2006).

New immigrants from Pakistan continue to enter the UK but at a lower rate than previous decades. This new dawn of immigration from Pakistan stem from more urban-centred "elite" backgrounds, with qualifications in medicine or engineering fulfilling specific roles in the labour market (Simpson *et al.*, 2010; Luthra and Platt, 2017). These migrants concentrate more into metropolitan areas such as London rather than northern industrial towns of the first wave of arrivals. Young Pakistani migrants continue to enter for study and work purposes (Larsen and Di Stasio, 2021). Whether student migrants from Pakistan are striving for long-term settlement varies; however, of all student migrant origins they have the highest proportion that stay after completion of study, of those issued study visas between 2004 and 2010 over 40% were granted leave to remain or settled status between 2011 and 2019 (Home Office, 2019). Migration does continue for family reunification purposes too, with elderly relatives coming to join children in the UK, and some migrations for arranged marriages (Charsley and Bolognani, 2021). But there is a demonstratable shift in the selection of Pakistani immigrants over time which has resulted in a group that is highly heterogenous with different characteristics in terms of human capital (Luthra and Platt, 2017; Larsen and Di Stasio, 2021). What does persist for Pakistanis in the UK is a strong attachment to religion, local areas, ethnic identity and social networks (Luthra and Platt, 2017; Harrison, Finney, *et al.*, 2023).

The growth in the ethnic Pakistani community now, is primarily through the descendants of the early migrants who came in the 1960's and 1970's. This longevity in the United Kingdom provides an opportunity to study successive generations with great statistical power due to the large sample size. By doing so we can observe differences between parents and their children across the different domains of the life course. Identifying how the hybridity of being Pakistani British manifests itself in behaviours compared to the trends seen amongst native born peers. The challenges faced by descendants differ from their parents: they have the advantage of British citizenship from birth, generally have language fluency, and face few legal barriers. But they face continued discrimination through blatant racist and Islamophobic attacks and, perhaps more importantly, through structural barriers and institutional problems that prevent a multicultural and multi-religious society from being viable (Abbas, 2007). Research continues to identify persistent labour market disadvantage (Heath and Di Stasio, 2019;

Li and Heath, 2020), housing disadvantage and residential segregation (Finney and Harries, 2015; Shankley and Finney, 2020; Harrison, Finney, *et al.*, 2023).

2.1.2. Pakistani migration to Norway

Norway is the only other European country, which has a large post-WWII group of Pakistani migrants. Recent estimates suggest 25,000 people born in Pakistan reside in Norway, with a further 17,000 Norwegian born descendants of Pakistani immigrants (Statistics Norway, 2023b). Historically, the migration patterns of Pakistanis into Norway have been similar to that of the UK context (Erdal, 2013; Larsen and Di Stasio, 2021), hence the comparability of the groups that underpins this research (see Figure 2.1 for visual representation). Norway changed from a country of emigration to one of receiving immigrants in the second half of the 20th century. Labour shortages resulted in widespread immigration of 'guest-workers' especially during the 1960's and 1970's (Isaksen, 2020), and one of the main origins of these migrants was Pakistan. Primarily this was men from the Punjab region, the same origin region of many of the migrants who moved to England. Guest worker employment was primarily in industrial manufacturing as low-skilled labourers (Friberg, 2012).

These guestworkers ended up settling permanently, and ultimately public pressure mounted to a more restrictive migration regime emerging in 1975 (Castles, 1986; Brochmann and Kjeldstadli, 2008). The restrictions on migration that followed changed the selection of migrants to one of family reunification, which remains a common stream of migrants from low-income countries into Norway (Friberg and Midtbøen, 2018). The labour market outcomes of these guest workers followed a trend whereby initially productivity and employment rates of these migrants was initially above that of the native population; however, this has regressed sharply over time (Bratsberg, Raaum and Røed, 2010). Much of this turbulence in employment is believed to be due to the industries that guestworkers, including those from Pakistan, were involved in being more vulnerable to economic downturns. Since the 1990's Pakistani born immigrants have consistently suffered lower employment rates compared to the majority population and other migrant groups (Bratsberg, Raaum and Røed, 2014). Labour market inequalities are more pronounced for women, who are employed at less than half the rate of Norwegian born women (Bratsberg, Raaum and Røed, 2014). This is

unsurprising given the lower prevalence of support within that community for women with children being in the labour market (Kavli, 2015). This attitude has shifted slightly between generations of Pakistanis yet they still are less supportive of labour market incorporation of mothers overall (Kavli, 2015) and the work of women is often undervalued (Nadim, 2016).

The labour market disadvantages have persisted into the second generation of Pakistani background in Norway. The gaps between the majority population and Norwegian-born Pakistanis are smaller than those between the immigrant generation and natives (Hermansen, 2016). However, field experiments find ongoing discrimination in access to the labour market (Midtbøen, 2015, 2016; Larsen and Di Stasio, 2021). Labour market penalties for failure to complete compulsory schooling are also higher for second generation Pakistanis compared to natives (Brekke, 2014). Even amongst Pakistanis who are economically successful in Norway their success has often been reliant on leveraging an ethnic niche, catering entrepreneurial endeavours to their immigrant and minority community, as opposed to accessing mainstream opportunities (Friberg and Midtbøen, 2018; Midtbøen and Nadim, 2019). Spatial assimilation of Pakistanis around Norway has not occurred in any great volume and they remain in Oslo where they initially settled (Magnusson Turner and Wessel, 2013). Within Oslo this experience of residential segregation has also worsened over time (Wessel, Turner and Nordvik, 2018; Hermansen, Hundebo and Birkelund, 2022).

2.2. Assimilation

Assimilation is theorised as the process by which subsequent generations of immigrants become progressively more similar to natives until they are non-distinct (Alba and Nee, 1997). It has often been framed around migrants and racial minorities in the USA, from works such as “Assimilation in American Life” (Gordon, 1964). However, migration into and between European countries also has a long history and thus assimilation and integration has been on the policy agenda in Europe since at least World War Two (Hansen, 2003). The process can take many generations and can be measured in a variety of ways that cover social, structural, civic and cultural aspects of behaviour and outcomes, thus making assimilation a broad topic across many disciplines (Lessard-Phillips, 2017; Heath and Schneider, 2021).

Examples of measures used to identify assimilation include demographic measures such as entry into unions with members of the majority (Qian and Lichter, 2007; Kulu and Hannemann, 2019) or aligning fertility behaviour with native populations (Gordon, 1964; Lichter *et al.*, 2012). It can also relate to housing trajectories such as similarities in tenure and spatial assimilation which measures the likelihood of migrants moving into residential areas dominated by the majority (Zorlu and Mulder, 2010; Vogiazides and Chihaya, 2020). Structural and social integration can be proxied for by the success of language acquisition (Dustmann, 1994) or the similarity of education progression and trajectories between immigrant generations and natives (Verhaeghe *et al.*, 2017). Further, economic measures, such as long term earning trends (Villarreal and Tamborini, 2018) can identify how similar groups have become over time and if they have experienced the same labour market progression as the majority population. Lastly, more subjective measures of cultural assimilation can be asked in surveys, relating to their attachment to the host society, its people, and their engagement with civic society (Angelini, Casi and Corazzini, 2015).

Not every group experiences this classical assimilation, which leads to the concept of segmented assimilation (Portes and Zhou, 1993; Zhou, 1997). Segmented assimilation is bound in the interrelationship between ethnic and migrant background alongside class identity (Bond, 2022). It extends the assumption of migrant groups becoming more mainstream and acknowledges that there can be downward trajectories on certain minority populations. These can relate to the development of enclaves and the racialisation of minority groups which prevents access to the mainstream (Portes and Zhou, 1993). The concept of segmented assimilation is rooted in racial differences in North America and its applicability to European contexts is debated (Kislev, 2019). However, there is evidence that segmented assimilation theory does hold in Europe in certain groups for example amongst the Turkish diaspora in Germany (Çelik, 2015).

Following the development of assimilation theories came other migrant and minority incorporation theories, notably multiculturalism (Kivisto and Faist, 2010). Multiculturalism recognises more the distinctiveness of cultures and diversity within the population and goes against the expectation that migrants change their behaviour to match the majority population. Instead, multiculturalism places more emphasis on recognising and championing cultural diversity that migration brings, and emphasises

that the presence of migrants changes social fabric of societies making them an integral part of the society they are now in (Bond, 2022).

Both Norway and the UK have social policies which largely pursue multiculturalism, accepting difference between population subgroups as inevitable and welcoming it (Koopmans, 2013). Thereby maintaining the importance of individual ethnic identities and difference under an umbrella of national unity and collective belonging (Modood, 2020). The success of multiculturalism in terms of social fabric and civic engagement is hotly debated and outwith the scope of this thesis (Koopmans, 2010, 2013; Brochmann and Djuve, 2013; Modood, 2020). However, there is concern that societal fragmentation can occur, with groups (migrant or ethnic minority) conforming more to their own group norms rather than broader society, which can lead to cultural entrenchment of behaviours. This last aspect shows a distinct similarity with segmented assimilation (Portes and Zhou, 1993) meaning multiculturalism and assimilation are not diametrically opposed and should be viewed as overlapping concepts (Bond, 2022)

This body of work is a social science endeavour analysing differences between aggregate groups of immigrants, their descendants, and the majority population across the domains of family formation patterns and health. Offering a contribution to the wider discourse of immigrant incorporation and how migrant populations change (or not) across generations. Exploring how the contextual factors in different destination countries might affect migrants with similar characteristics on entry differently. It must be acknowledged that the contextual factors at play can include systemic discrimination which perpetuates the reproduction of social inequality in a way that creates a barrier to assimilation (Safi, 2024). Moreover, these inequalities can be present in a way that suggest a lack of assimilation, but is actually a factor of class inequality and intergenerational transmission of low parental socioeconomic resources (Drouhot and Nee, 2019; Bucca and Drouhot, 2024)

This work primarily uses an assimilation-based approach due to the methodological design which uses quantitative methods to identify differences in the life courses between generations. Moreover, life satisfaction is found to be positively associated with assimilation and attachment to the host society (Angelini, Casi and Corazzini, 2015). Often, there is also an expectation or desire in majority populations for at least

some acculturation to native-like behaviours, which can vary depending on the migration stream and the migrant generation (Kunst and Sam, 2014), there can be consequences for social cohesion. But to be clear I wish to separate myself from normative assumptions which imply that there is a particular way immigrants *'should'* behave, nor do I wish to diminish the heterogeneity and diversity that is prevalent within groups (Vertovec, 2007). Importantly, the onus should not be on immigrants and their descendants to change, rather it should be on policymakers to diminish inequalities.

2.3. Migrant fertility and family formation

Experiencing family formation trajectories with similar tempo and quantum of the majority population is seen as a key barometer of integration and assimilation to mainstream society (Kulu *et al.*, 2019; Wilson, 2019), as it suggests adoption of cultural influences and preferences present in the destination. The extent to which immigrants and their descendants' family formation pathways change to match that of the majority population is highly variable and contextual based on both origin and destination factors and individual circumstances and preferences (Kulu and Milewski, 2007; Mikolai and Kulu, 2022c; Mussino and Cantalini, 2022; Liu and Kulu, 2023). Several theories have emerged which attempt to explain differences which will now be outlined. These theories are non-exclusive and are linked to each other and wider experiences of migrant incorporation such as socioeconomic success. Further specification of these hypotheses can be found in the literature, see (Andersson, 2004; Kulu, 2005; Milewski, 2010a; Wilson, 2015) amongst others.

2.3.1. Disruption

The migration process can alter family dynamics through disruption of the life course. For example, the period around migration causes a hindrance to partnership formation or separation from a partner (Lindstrom and Saucedo, 2002). Migration streams where it is common for one member to go as a forerunner and leave a partner in the origin country are more prone to these periods of separation and fertility disruption (Mussino and Cantalini, 2022). Migration also brings economic costs and uncertainty and is a major stressor on the life course, these can negatively influence either the ability to find

a partner to have a child with or depress fertility desires within a couple due to the economic constraints they are subjected to due to migration (Hervitz, 1985). Often findings about disruption have concluded that after the initial migration period and depressed fertility, there is an acceleration or 'catch-up' period, meaning that the outcome is a change in fertility tempo and not overall quantum (Goldstein and Goldstein, 1981; Ford, 1990).

2.3.2. Interrelated life course events

There has been conflicting findings on the extent of fertility decline after migration, some findings suggest that in the period just after migration there is no evidence of disruption (Andersson, 2004; Milewski, 2007). Some argue that this is due to large numbers of migrations that are explicitly linked to family formation or reunification processes. The processes of partnership formation and fertility are not totally distinct from migration and thus the interconnectedness of these events in the life course should be considered (Milewski, 2007). Quantitative research has indicated that these events are in fact correlated in some groups and that the migration process is positively associated with family formation and fertility, with an 'arrival effect' on fertility (Mussino and Strozza, 2012; Robards and Berrington, 2016). The interconnectedness of these elements of the life course is why increasing attention is paid in migrant research to the ordering of life events and the application of a life course approach (Wingens *et al.*, 2011).

2.3.3. Selection

Selection of immigrants is an underlying principle for all studies that compare migrants to native populations no matter the domain of interest. Those who migrate are not necessarily representative of the origin population (Borjas, 1987; Chiswick, 1999). They often have socioeconomic characteristics that place them in higher status of society in the origin country and this means that their family preferences are adjusted as such, typically that they will enter unions later and delay fertility to prioritise education and career opportunities. In addition, a migrant a more likely to select a destination country which has values more closely aligned with individual level fertility preferences (Kulu, 2005). For example, immigrants from areas with high prevalence of direct marriage and low divorce might be more inclined to enter cohabitations and experience divorce,

compared to the stay behind population. These value driven differences have been particularly apparent in studies looking at internal migrants moving between rural and urban areas (Courgeau, 1989; White, Moreno and Shenyang Guo, 1995).

Moreover, prior family formation and pro-natalist attitudes can be associated with selection out of being a migrant, it is known that those with the lowest likelihood of migrating are those with children (Toulemon, 2004), as both the economic and non-economic costs of migrating with children are much higher. This results in the pool of individuals who are likely to migrate being more likely to prefer voluntary childlessness or low parity. There will also be individuals who select into migration with fertility intentions in the destination, but there is still a selection into postponement of fertility in order to reach the socioeconomic level which can support migration (Wilson, 2020).

2.3.4. Socialisation

Socialisation theory states that the early age experiences of immigrants are what shape future family preferences and therefore fertility outcomes (Goldberg, 1959; Andersson, 2004; Toulemon, 2004; Kulu and Milewski, 2007; Milewski, 2010b; Dubuc, 2012). This theory is based on findings which show that even after prolonged periods in the destination country, norms can remain in line with what is seen in the origin country. This is particularly prevalent for immigrants from origins which are more conservative, conservative meaning earlier marriage and larger family size norms, as the importance of family formation can be ingrained as more important early in the life. Socialisation is of explicit interest around the timing of migration, for those who migrate during those formative years there are competing options which could dictate what norms they are socialised around (Adserà *et al.*, 2012). If migration is late into childhood the preferences may already have been formed implicitly. However, earlier migration may result in extensive socialisation with the majority population, for example in educational institutions, leading to preferences converging to native levels. There is even more complexity when considering the residential context, as even if migration occurs in the early life the local context may be highly concentrated with co-ethnics so socialisation with the majority may not occur. This has been demonstrated in literature with higher fertility amongst those who experience residential segregation (Wilson and Kuha,

2018), though, of course, the potential for selectivity in those who reside in more ethnically segregated areas may be patterned by fertility intentions.

2.3.5. Adaptation

The adaptation hypothesis predicts that over the life course fertility of immigrants will converge with that of the host population (Andersson and Scott, 2005; Milewski, 2010a). Meaning that between generations less conservative family behaviour will become more common for immigrants from higher fertility origins (Delaporte and Kulu, 2022). This process happens over time to gradually lead to immigrants becoming indistinguishable from natives (Kahn, 1988; Milewski, 2007). It can be seen more clearly for those who arrive earlier in the life course or as children, who adapt faster, thus time since migration and age at migration are important aspects to consider in this process (Adserà *et al.*, 2012). Logically, the more fertile years spent in the destination country the bigger the influence that context will have (Mayer and Riphahn, 2000). What is important to consider is that evidence of adaptation may not actually reflect changes in preferences, but more so be a condition of the constraints placed upon migrants by the economic, social, and political structure of the destination. These constraints thus rendering the previous fertility desires which they would have in the origin as unattainable (Gordon, 1964; Ford, 1990; Andersson, 2004).

2.3.6. Subculture and minority group status

The subculture hypothesis suggests that the status of being a migrant or minority group has an independent effect on the family formation behaviours displayed (Milewski, 2010a). In cases where the dominant norm of the origin population is large family size, early transitions to direct marriage, coupled with low usage of birth control then the belonging to such a group is going to act as an elevator of fertility (Goldscheider and Uhlenberg, 1969). This theory is especially relevant for the descendants of immigrants who can experience socioeconomic disadvantage and downward assimilation into the subculture formation (Portes and Zhou, 1993). As mentioned, this can also result in residential segregation or enclaving which can influence the socialisation of subsequent immigrant generations (Wilson and Kuha, 2018) and further persist the entrenchment of fertility and family behaviours (Wilson, 2015; Kulu *et al.*, 2019).

The minority group status hypothesis also posits that there is an independent effect of being a minority but focusses more on the psychological aspects of experiencing discrimination, which render feelings of being marginalised and development of frustration, this materialises in a desire to have lower fertility and slower union formations (Milewski, 2010a). This primarily differs from the subculture hypothesis as it assumes that those in the minority group who have higher socioeconomic standing will seek to restrict their fertility to improve their standing in society, economically to enable social mobility. The contrary to this is that for those with low socioeconomic status in the minority group the subculture hypothesis would hold (Bean and Tienda, 1988).

2.4. Migrant health disparities

Previous studies have addressed health inequalities between natives and immigrant or minority groups through various measures such as mortality (Wild *et al.*, 2007; Scott and Timæus, 2013; Wallace and Kulu, 2014, 2015), self-reported health (Evandrou *et al.*, 2016), life expectancy, including disability free life expectancy (Rees, Wohland and Norman, 2009; Wohland *et al.*, 2015) and, multimorbidity (Charles, 2021). Findings suggest that immigrants experience a mortality advantage (Honkaniemi *et al.*, 2017; Aldridge *et al.*, 2018; Shor and Roelfs, 2021). However, despite this lower mortality there are findings that the foreign-born population can spend more time with morbidities and in worse health, referred to as the migrant health mortality paradox (Wallace and Darlington-Pollock, 2022).

The focus of this thesis is on two health outcomes, neoplasm development and subsequent cancer mortality, followed by all-cause mortality. What follows is an overview of previous research on the health of migrants and descendants. First, an overview the migrant mortality advantage and the explanations offered for it. Second, detailing the rapid health transmission which is a theoretical underpinning of why immigrants often benefit from the process of migration, especially relating to the causes of mortality. Third, there is an overview of the health of descendants. Recent findings indicate that the socioeconomic disadvantage of minority status accumulates into poor mortality outcomes and health behaviours of the children of migrants compared to their parents.

2.4.1. Migrant mortality advantage

The migrant mortality advantage is a paradox whereby immigrants are found to have lower mortality risks and therefore higher life expectancies than the native population, despite having relatively lower socioeconomic outcomes (Razum, 2008). It has been found consistently across a variety of contexts including: Belgium (Anson, 2004; Vandenheede *et al.*, 2015; Vanthomme and Vandenheede, 2019b), France (Boulogne *et al.*, 2012; Wallace, Khlat and Guillot, 2019), Scotland (Bhopal *et al.*, 2018), Germany (Kohls, 2010), Switzerland (Tarnutzer, Bopp and the SNC study group, 2012; Zufferey, 2016), Costa Rica (Herring *et al.*, 2010), Denmark (Norredam *et al.*, 2012; Jervelund *et al.*, 2017), Finland (Lehti *et al.*, 2017), New Zealand (Hajat *et al.*, 2010), Greece (Verropoulou and Tsimbos, 2016), USA (Eschbach *et al.*, 2007; Nasseri and Moulton, 2011) and Canada (DesMeules *et al.*, 2005). Moreover, there are a variety of systematic reviews which synthesise the findings (Honkaniemi *et al.*, 2017; Aldridge *et al.*, 2018; Shor and Roelfs, 2021). Most relevantly for this thesis the paradox has been found in both England and Wales (Harding, 2003; Wild *et al.*, 2007; Wallace and Kulu, 2014, 2015, 2018) and Norway (Syse *et al.*, 2016, 2018).

The effects of this migrant health advantage over time are mixed. Some find that longer duration in the host country reduces the advantage, making it most pronounced between ages 20-40 (Wallace and Kulu, 2014; Constant, 2017; Wallace and Wilson, 2019; Wallace, Khlat and Guillot, 2019; Constant and Milewski, 2021). Assimilation theory suggests that the mortality advantage will reduce over time as migrants adopt behaviours associated with poorer health and the development of chronic illnesses more common western nations (Parkin and Khlat, 1996; Vandenheede *et al.*, 2015) although some studies find little reduction in the migrant health advantage with length of residence and therefore ageing (Anson, 2004; Juárez *et al.*, 2018). Research in Germany has seen the advantage reverse at older ages, with migrant mortality higher relative to natives (Goettler, 2020). Furthermore, studies from the Survey of Health, Ageing and Retirement in Europe (SHARE) indicate that migrants in older ages may be descending into worse health at higher rates compared to non-migrants (Reus-Pons *et al.*, 2018). These conflicting results suggest that the contextual elements related to policy, integration and resources are important in determining and overcoming inequalities in health outcomes.

The mechanism behind the adoption of negative health behaviours which leads to the loss of this mortality advantage can be inherently linked to having a migrant or minority status (Wallace, Khlat and Guillot, 2019). The accumulation of disadvantage can have detrimental impacts on health for immigrants that may negate the mortality advantage (Spallek, Zeeb and Razum, 2011; Loi and Hale, 2019). This disadvantage can include both socioeconomic deprivation (Nazroo, 2003; Reus-Pons *et al.*, 2018; Goettler, 2020) and experiences of discrimination, particularly impactful for mental health (Nazroo, 2003; Wallace, Nazroo and Bécares, 2016). This shows the complication of health assimilation, where exhibiting more 'native-like' health behaviours over time is firstly, not necessarily good for the immigrant population (Antecol and Bedard, 2006), and secondly can be a condition of the material deprivation that is more prevalent in migrant communities (Loi and Hale, 2019).

There are competing hypotheses which seek to explain the apparent advantage in immigrant health. First, health selection, with those that experience migration coming from a certain subset of the origin population who are in better general health than the non-migrants and this group therefore have above average health in the destination country (Abraido-Lanza *et al.*, 1999; Chiswick, Lee and Miller, 2008; Constant, 2017; Constant and Milewski, 2021). Some argue that selection alone is not sufficient and that the context and purpose of migration is important is also important, for example whether migration is voluntary or not (Anson, 2004). Moreover, origin countries which are most similar to the destination, for example neighbouring countries or those which are culturally similar, experience less of an advantage since selection is less relevant to the migration process (Wallace and Kulu, 2014; Juárez *et al.*, 2018).

A second explanation of migrant health advantage is the maintenance of positive health behaviours amongst immigrants, for example less smoking, lower alcohol intake, better diets, and maintenance of other, healthier habits than the native population (Abraido-Lanza *et al.*, 1999). This is used to partially explain differences in mortality patterns between natives and immigrants. However, there are debates on the strength of this as migrants have lower mortality than those who remain in the origin implying that there is something inherent to migrants or migration experience beyond the typical behaviours of those from that origin (Wallace and Wilson, 2019).

A third possibility is that the advantage is a data artefact, more specifically that there is over coverage in population statistics of immigrant groups because onward or return migration is often not recorded thus, making them appear immortal in analysis (Kohls, 2010; Monti *et al.*, 2020). Whilst this source of bias does exist the advantage has been found to remain even when over coverage is accounted for (Wallace and Kulu, 2014; Wallace and Wilson, 2022).

Fourth, there is potential selective return migration to the origin country in later years of migrants in poor health, or the salmon bias hypothesis (Abraido-Lanza *et al.*, 1999; Guillot *et al.*, 2023). It has been found that Hispanic immigrants in the USA who experience health decline, are more likely to return to their origin country (Diaz, Koning and Martinez-Donate, 2016). Logically, this shows that the salmon bias hypothesis is plausible, however it is hard to investigate thoroughly since information on the mortality of out-migrants is scarce. Evidence in France using pension records shows that this can be an explanation for the lower migrant mortality with return migrants having significantly elevated mortality (Guillot *et al.*, 2023). Salmon bias has also been observed amongst internal migrants with elevated mortality of migrants who return to northern Sweden from the south (Andersson and Drefahl, 2017). However, in England and Wales whilst evidencable the salmon bias hypothesis cannot fully explain the migrant mortality advantage (Wallace and Kulu, 2018). Further the existence of mortality advantages at younger ages alleviates the idea that selective out migration is the sole explanation for a migrant mortality advantage (Wallace and Wilson, 2019). These conflicting results suggest that there are factors associated with both the origin and destination context which alter the likelihood of return migration.

Lastly, are potential genetic mechanisms that alter the susceptibility of some immigrant groups to certain medical conditions. There is evidence of familial inherited susceptibility to cancer however this is not seen as a major influence on population level cancer statistics (Lindor *et al.*, 2008). Additionally, experiences related to historical famine in the origin country can alter the epigenetic make-up of the migrating population (Bygren *et al.*, 2014). There are also origin effects which alter vulnerability to infection related cancers, such as liver cancer associated with Hepatitis B, which are often found to be higher amongst immigrant groups in high income countries (Vanthomme and Vandenheede, 2019b).

2.4.2. Migration as a rapid health transition

When migrants move from a less developed country to a more developed one they benefit from a rapid shift in the phase of the health transition that they are exposed to (Razum, 2006). Prior to this migration the risk of mortality and ill health is typified by higher risk of accidental death and increased risk of infection related morbidities, in a setting with lower coverage of healthcare infrastructure. Following the migration to a high-income country these risks quickly dissipate with availability of better healthcare infrastructure and improved standard of living. Over time in the host country the risk of chronic illnesses will increase as the accumulated risk factors they are exposed to in the destination country neutralise the availability of better healthcare and lower risk of infectious disease and accidental deaths (Spallek, Zeeb and Razum, 2011). Thus explaining why child migrants do not experience a health advantage to the same extent, since their extended life course in the destination country and their adaptation of 'native-like' health behaviours aligns them more with the majority (Harding, 2003; Shor, Roelfs and Vang, 2017). Research in Belgium confirms that '*migration as rapid health transition*' co-exists with the migrant mortality advantage; there western migrants who had already been exposed to chronic disease risk factors in early life experience a faster transition to chronic diseases in later life compared to non-western migrants. Moreover, infectious disease mortality remains elevated for migrants from less industrialised countries who have been exposed to more infectious disease risk factors in their early life (Vandenheede *et al.*, 2015).

The change in mortality risks over time highlights how life course experiences, such as migration can alter the risk profile that individuals are subjected to (Marmot, Adelstein and Bulusu, 1984). Cancer and neoplasm development can be used as a prime example of this. There is much heterogeneity in the type of cancers (one of the key outcomes in this thesis) that inflict non-western immigrants compared to natives. In developing countries cancers driven by lifestyle factors are low in frequency (Parkin, 2004), however the risk of infectious diseases such as hepatitis is high. These infections remain a risk after migration and are associated with an elevated risk for certain cancer types such as liver or stomach in the destination (Spallek, Zeeb and Razum, 2011; Hjerkind *et al.*, 2020). Cancers linked to lifestyle and environmental factors generally remain lower for non-western migrants, compared to natives and migrants from culturally similar

places, however over time the risk will increase due to acculturation and could become similar to natives in the later life course (Harding, Rosato and Teyhan, 2009; Arnold, Razum and Coebergh, 2010; Mousavi and Hemminki, 2015).

2.4.3. Descendants' health

Mortality studies of the second generation are limited due to the younger age structure of the group which means fewer death events upon which to estimate mortality robustly. However, the consensus across much of the literature is that the outcomes of migrant descendants is highly contextual. This is evidenced by the globally mixed results for the mortality of descendants in adulthood. In Switzerland those with a foreign background are found to have lower mortality rates (Zufferey, 2016), although not the case for descendants of Italian migrants in Switzerland (Tarnutzer, Bopp and the SNC study group, 2012). US born Latin Americans also appear to have a health advantage over US born Whites (Abraido-Lanza *et al.*, 1999). In Sweden the mortality advantage found amongst first generation immigrants is reversed for their descendants (Wallace, 2022), this is seemingly related to increased deaths at younger ages from external factors such as accidents, suicides related to mental health disorders, and substance misuse. Findings in the UK suggest little variation in self-reported health between the foreign born and the UK born descendants (Smith, Kelly and Nazroo, 2009), however native-born ethnic minority groups do seemingly lose the mortality advantage that their immigrant ancestors have (Scott and Timæus, 2013; Wallace, 2016).

The theoretical perspective of the health outcomes of the descendants group differs to the immigrant generation theories. Descendants do not experience the selection mechanisms of their parents thus the healthy migrant paradox and rapid health transition are not as relevant in explaining health differentials. Data artefacts and salmon bias via return migration are also less of a factor. Those with a second-generation background are known to be more mobile in some contexts, for example second generation Western Europeans in Netherlands (de Jong and de Valk, 2023). However, whilst those from less developed backgrounds often exhibit strong return intentions (Bettin, Cela and Fokkema, 2018) the actual achievement of these intentions is restricted by the limited opportunities in the parental origin (Çelik and Notten, 2014). The UK context finds that return migration is rarest for those from the Indian subcontinent due to the large

economic inequality between origin and destination (Dustmann and Weiss, 2007). Thus, over coverage of Pakistani second generation in administrative data of England and Wales is unlikely.

Positive health selection is also less of a factor for the descendants of immigrants, inheritance of good genetic disposition is possible (Spallek, Zeeb and Razum, 2011), and evidence exists that parental longevity is correlated with their offspring's longevity (Gudmundsson, Gudbjartsson and Kong, 2000). However, for diseases such as cancer which are overwhelmingly driven by environmental factors and lifestyle more than epigenetics (Brown *et al.*, 2018), there is intrigue about how behavioural changes between generations can influence health and mortality. The adoption of more unhealthy behaviours is one of the explanations into why the mortality advantage is lost, possibly reversed, for descendants of immigrants (Wallace, 2016; Wallace, Hiam and Aldridge, 2023). For immigrants, increased exposure time in the destination is associated with deterioration of the benefits of positive selection (Harding, 2003), and the adoption of unhealthy behaviours such as, reliance fat rich foods (Jamal, 1998) and increased smoking (Nazroo, 1997). Hence for descendants, who experience entire life courses in the destination country, the logic would suggest that this group would assimilate to more negative health behaviours. Where descendants of immigrants can experience an advantage compared to the immigrant generation is through lower barriers to healthcare access, owing to better language fluency, knowledge of, and familiarity with the healthcare system. This then makes engagement with screening and intervention programs more likely, although these barriers can still persist between generations (Balcazar, Grineski and Collins, 2015; Bhargava *et al.*, 2018).

2.5. The welfare state

The purpose of a welfare state is to redistribute income via taxation and implement social policies to reduce socioeconomic inequalities and poverty (Kenworthy, 1999; Moller *et al.*, 2003). This makes it an important contextual determinant of various life course domains, which are driven by socioeconomics including that of labour market access, (Koopmans, 2010), family formation and fertility pathways (Neyer, 2013), and morbidity and health inequalities (Eikemo *et al.*, 2008; Bambra, Netuveli and Eikemo,

2010). Migrant incorporation regimes can also be intrinsically linked to the welfare state provision (Bommes and Geddes, 2000).

Welfare state regimes are unique across geography, the typologies of the modern welfare state in high income countries comes from seminal work by Esping-Andersen (1990). Both Norway and the UK, have neo-liberal economies, Norwegian social support is more generous and universal under what is known as a Scandinavian social democratic model. Whereas UK social support is more mixed in coverage sometimes universal but often focusses explicitly on the poorest of the population, thus a liberal model typical of Anglo countries (Esping-Andersen, 1990; Ferrera, 1996).

There is an expectation that native-immigrant differences in socioeconomic positions, labour market success, family outcomes and even health will be smaller in countries with inclusive integration policies and/or a wide range of policies that reduce differences between population subgroups to promote social equality (Esping-Andersen, 1999). However, there has been extensive debate about the impact that an increasingly multicultural society has on the welfare state and the effectiveness of the welfare state in eradicating differences between natives and immigrants (Kymlicka and Banting, 2006). In theory, under an assimilation perspective (Alba and Nee, 1997) usage of the welfare state over time should not differ between groups, and the gap between richest and poorest minimal. This though is not the case in either Norway or the United Kingdom. In Norway immigrants (particularly those of non-Western origin) are overrepresented amongst the poorest (Galloway and Aaberge, 2005), which is also the reality for many immigrant and ethnic minority groups in the UK (Platt, 2007). Research from the US has also indicated that intergenerational transmission of welfare dependency is likely (Borjas, 1987), and amongst migrant groups who have experienced downward assimilation (Portes and Zhou, 1993) this is more prevalent. However, the applicability of findings from North America can be questioned since the welfare state and political environment is highly distinct from what is found in European countries. In Norway, social mobility between generations can be supported by the welfare state and the descendants of immigrants use less social assistance compared to the immigrant generation, but still at rates above natives (Smedsvik, Iacono and D'Agostino, 2022).

Contrary to some findings that welfare state generosity decreases poverty (Kenworthy, 1999; Moller *et al.*, 2003), there is an argument that overtly generous social assistance (typical of Scandinavian welfare states) is less likely to reduce poverty and inequality (Korpi and Palme, 1998). Previous work that has compared welfare regimes has found that wealth inequality has been greater in Scandinavian style regimes (in this case Sweden) compared to liberal models of welfare in the UK and Germany (Kesler, 2015), importantly though overall rates of poverty are found to lower in these Social Democratic model. The byproduct of this is that within the poorest groups of society remains immigrants and minorities. Structural barriers that the welfare state cannot overcome remain in place for immigrants. For example, high generosity is thought to lower the possibility of language development among immigrants which has repercussions for labour market attainment (Koopmans, 2010). Moreover, high generosity can lead to experiences where those with many dependents are disincentivised from work, perpetuating overall dependence (Bratsberg et al., 2010). Findings do suggest that the relatively low level of welfare state provision in the UK is a factor in the relatively high rates of labour market participation amongst immigrants (Koopmans, 2010).

2.5.1. The welfare state and health inequalities

One of the studies in this thesis is a comparison of migrant mortality in two high income contexts, this paper allows for inference about how the welfare state generosity interacts with the native-minority gap in mortality. Differences in mortality and life expectancy between countries can be related to the welfare state with positive associations between economically generous welfare regimes and longevity (Nelson and Fritzell, 2014). The social welfare contexts of Norway and the UK differ, whilst both have neo-liberal economies, Norwegian social support is more generous and universal. UK social support whilst universal in some capacities, including healthcare, generally focusses only on the poorest of the population (Esping-Andersen, 1990). The differences can be described as a more liberal approach in the UK compared to a social democratic approach in Scandinavia (Ferrera, 1996). There are similarities in healthcare policy too, both have National Health Services, where the ability to pay does not influence access to treatment and care, in both contexts private healthcare utilisation is low (Saunes,

2020; Thorlby, 2020). Although, private healthcare is increasingly expanding in the UK as an alternative to a faltering National Health Service (Kirkwood, Pollock and Roderick, 2024).

The existence of universal health care should reduce health inequalities overall (Asaria et al., 2016). However, barriers to accessing healthcare remain in both Norway and the UK, particularly for those from ethnic minority and migrant backgrounds (Saleem, Steadman and Fejzic, 2019; Kapadia *et al.*, 2022). Moreover, in Norway there exists a dichotomy between assimilation and multiculturalism in the social welfare models, where the pursuit of multiculturalism is somewhat opposed to classical assimilation trajectories (Brochmann and Djuve, 2013). This is somewhat of a paradox since the socioeconomic inequalities are smaller due to the high-income support, but these multiculturalist approaches can be ineffectual in addressing health inequalities between social strata (Hurrelmann et al., 2011). In Scandinavian contexts disadvantaged strata, often those of migrant background, can feel distant from society and that they are not contributing, this results in lower self-worth and group members may have lower motivation to protect their health (Hurrelmann et al., 2011). This welfare state paradox has been observed across self-reported health and life limiting illness measures (Eikemo *et al.*, 2008; Espelt *et al.*, 2008; Bambra, Netuveli and Eikemo, 2010).

2.6. Contribution

Whilst migrant fertility and family formation, including the behaviours of descendants has been researched extensively. UK research has seldom studied union formation and fertility simultaneously. Therefore, prior studies were unable to identify differences in the ordering and tempo of family processes between natives, Pakistanis, and their descendants. Those that have, have used sequence analysis techniques, but limited it to the period of time around migration, and not the entire life course (Mikolai and Kulu, 2022a). Additionally, research has explored different analytical strategies such as multistate event history models (Mikolai and Kulu, 2022c). Moreover, UK research on migrant outcomes has commonly combined Pakistani and Bangladeshi populations, (Berrington, 1994; Dubuc, 2012; Kulu and Hannemann, 2016; Wilson, 2019). This can be justified however, there is heterogeneity between these groups (Modood *et al.*, 1997;

Peach, 2006; Dale and Ahmed, 2011) that could result in different assimilation pathways. Therefore, studying the Pakistani group alone is important.

There are similar gaps in the study of Pakistani's health outcomes. It is common for a combining of Pakistanis and Bangladeshis often with other South Asians too (Wild *et al.*, 2006; Mangtani *et al.*, 2010; Maringe *et al.*, 2015; Wallace and Kulu, 2015). In addition, many studies on migrant health differences are conducted based on ethnic group, thus combining immigrants with their descendants (Winter *et al.*, 1999; Jack, Davies and Møller, 2009, 2010; Delon *et al.*, 2022), this method does not allow for health acculturation to be studied. Moreover, usage of individual level data which can allow the exploration of socioeconomic factors has not truly been explored. Lastly, the use of administrative data to study both cancer incidence and subsequent cancer mortality on migrant populations has yet to be done. Previous research has generally looked at one of the outcomes, and where it has looked at both the analysis has been limited to certain geographic areas of England, and specific types of cancer (Jack, Davies and Møller, 2009, 2010; Jack *et al.*, 2013).

The first two chapters of the thesis have specific intentions to address gaps related to Pakistani origin populations in the UK or England and Wales relating to family formation and cancer. These are then placed into a comparative perspective with Norway in the final discussion chapter. The final paper has great novelty as it directly compares a population from the same origin in two distinct countries. It compares migrant mortality, and due to the different welfare states in England and Wales and Norway, contributing to the literature on how the migrant mortality advantage intersects with the welfare state and health inequalities. As yet no studies have been able to do this with the Pakistani diaspora, cross national studies around migrant mortality have been limited to literature reviews (Honkaniemi *et al.*, 2017; Aldridge *et al.*, 2018; Shor and Roelfs, 2021) or have had a focus on the Turkish diaspora and specific causes of death (Spallek *et al.*, 2012). Further, it adds to and extends existing literature relating to the transmission of the migrant mortality advantage between generations in England and Wales and Norway (Wallace, 2016, 2022; Wallace, Hiam and Aldridge, 2023). This allows for interpretation of health acculturation and subsequently infer how assimilation is occurring in the two contexts.

3. Data and Methods

3.1. Data

To address the research questions, we use quantitative methods relying on three different sources of data, survey data from the UK Household Longitudinal Study, administrative data of England and Wales in the Office for National Statistics – Longitudinal Study (ONS-LS) and finally for Norway we use administrative data from the Norwegian population register.

3.1.1. Understanding Society (UKHLS/BHPS)

In chapter one we use data from the UK Household Longitudinal Study (UKHLS), also known as Understanding Society which launched in 2009 (University of Essex Institute for Social and Economic Research, 2021). This data is harmonised with an older panel survey The British Household Panel Survey (BHPS) which ran 1991-2009. This is a large-scale panel survey which collects data annually from a nationally representative sample of households in the UK. The study covers a wide range of topics, including employment, income, education, health, family structures, and subjective well-being. All adult household members are asked to recall retrospective information relating to fertility and partnership dynamics, hence the application of longitudinal methods to study life courses becomes possible no matter how many waves they appear at. This study is designed to highlight the diversity of the UK and allow for statistical analysis which studies immigrants and minority groups. To do that more households in ethnically dense areas were selected and boost samples have been used to include more minorities. Complex weights are provided with the data to make sure that despite this the survey is generalisable to the population.

3.1.2. Office for National Statistics-Longitudinal Study

For chapter two about cancer in Pakistanis and Bangladeshis in England and Wales, and also chapter three which studies immigrant mortality in a comparative perspective we use the Office for National Statistics-Longitudinal Study (ONS-LS) of England and Wales (Office for National Statistics, 2019b). The ONS-LS contains linked census and life events data for a representative 1% sample of the population of England and Wales.

An individual becomes part of the ONS-LS if they are born on one of four unspecified birth dates. The individual level data is from at the decennial census beginning in 1971, this is then linked to life event dates such as emigration, re-entry, death, and cancer diagnosis collected from National Health Service (NHS) registrations and de-registrations. In the absence of a population register this is the largest individual level dataset in England and Wales.

The sample has several advantages for this research. It is incredibly rich and benefits from having information of over half a million people which makes it the largest individual level dataset available in England and Wales. Further, because it links census records to NHS records there is a high level of detail over a substantial amount of time. This means that powerful longitudinal studies can be performed. Lastly, because the sample is so large for the major immigrant groups sample sizes are healthy. Moreover, using questions relating to place of birth and ethnicity it is possible to disaggregate immigrants from their descendants and look at generational changes. Unfortunately, the removal of questions about parental country of birth (only asked at the 1971 census), means that more detailed information relating to which generation of immigrant they are, is harder to obtain. Yet an aggregated descendants group for topics related to later life health and mortality will be dominated by the second generation due to the timelines of immigration. complicated.

3.1.3. Norwegian Population Register

The Norwegian register is a full coverage population register administered by Statistics Norway. The register records the vital events, including union formation and dissolution, childbearing, migrations, and deaths of all individuals living in Norway since 1970. This information is supplemented with further data available from Statistics Norway, relating to education and income. Which gives a high level of detail about the socioeconomic and demographic characteristics of the population over time. Analysis in this thesis used information from the National Education Database (NUDB) which contains the education level reached by an individual.

The register gives the ability to link parents to their children meaning that parental country of birth can be studied for all people born after 1953 whose parents survived until 1970. This means that clear identification of the second generation and their

specific parental origin is possible. It also provides the entry dates of immigrants with high specificity. Like the ONS-LS the register provides the opportunity to longitudinally follow the population and study transitions into various demographic events. Moreover, the coverage of immigrants in the data is very strong. This is because the management of these registers is done through an identification number, this number is the foundation of many public services and institutions such as banking, education systems and access to the welfare state. Immigrants who intend to stay in Norway for more than six months are required to register with the authorities and due to the desire to access this identification number, and the institutions that require it, the incentive to register is very high (Bratsberg, Raaum and Sørlie, 2007).

3.2. Methodologies

To uncover the differences between native population, immigrants, and their descendants the application of distinct methodologies is necessary. This collection applies different methodologies in each chapter;

1 Chapter 1 applies Multichannel sequence analysis (MCSA), clustering and multinomial logistic regression.

2 Chapter 2 is an application of event history modelling and Cox proportional hazards models.

3 Chapter 3 also uses event history analysis; however, with the outcome being death we apply a parametric Gompertz model (Lee and Wang, 2013)

The use of these advanced longitudinal methods provides a methodological contribution to the field of immigrant assimilation studies. Chapter 1 is the first application of multichannel sequence analysis to look at differences within generations of the Pakistani group in the United Kingdom, and one of the first applications of sequence analysis on immigrant minorities in the United Kingdom (Mikolai and Kulu, 2022b). Chapter two is one of the first uses of individual level longitudinal data to identify cancer incidence and subsequent cancer mortality differences. The application of flexible Cox proportional hazards models is novel and extends on previous migrant cancer studies in the UK context which have looked solely at cancer mortality (Mangtani *et al.*, 2010). Lastly, chapter three is, to our knowledge, one of the first

comparative studies on migrant mortality which uses individual level data. Previous comparative research has focused on life expectancy of migrants in different contexts (Wallace *et al.*, 2022) or on a specific cause of death for a specific migrant group notably the cancer mortality of the Turkish origin group in European countries (Spallek *et al.*, 2012).

3.2.1. Multichannel sequence analysis

Sequence analysis is an approach which allows researchers to explore the complex interplay of different life course domains (Abbott, 1995). Multichannel sequence extends on traditional sequence analysis by considering multiple variables over time (Pollock, 2007). Allowing for nuances and complexities to be explored in a more holistic manner as opposed to cross sectional measures (Aassve, Billari and Piccarreta, 2007).

Once sequences that cover the life course domains of interest are made they can be compared to other sequences and an optimal matching algorithm can measure how similar they are to each other (Abbott and Forrest, 1986). Using this distance similar typologies can be clustered together in a way that "minimises within-cluster and maximises the between-cluster distance" (Mikolai and Lyons-Amos, 2017).

3.2.2. Multinomial logistic regression

The clusters identified through sequence analysis and hierarchical clustering represent the most common typologies of the life course experienced, but are only a descriptive method of presenting the data (Pollock, Antcliff and Ralphs, 2002). These identified typologies can then be the outcome variable in a Multinomial Logistic Regression. This can help identify which personal characteristics, such as immigrant background or birth cohort, are associated with specific pathways.

3.2.3. Event history analysis

Event history analysis is a statistical method which analyses the time until an event of interest occurs. This approach is particularly valuable in life course research and epidemiology where it is widely used to identify transitions. This method is useful when studying events that have a temporal dimension, such as the duration until marriage,

unemployment, or any other significant life event. It is advantageous in comparison with cross sectional methods as it is not affected by attrition and individuals who are censored can still be used in analysis. The method allows for the inclusion of time-varying covariates, understanding that factors which influence events during the life course are dynamic rather than static.

The study on cancer incidence and mortality uses survival analysis and applies Cox proportional hazard models which are a semi-parametric model. This offers flexibility in the devising of models predicting cancer incidence and subsequent cancer mortality. The study of migrant mortality across the two destinations applies a parametric survival model, namely the Gompertz model. This is commonly used for mortality studies, which assumes an underlying shape that mortality increases exponentially in the life course (Lee and Wang, 2013).

4. Union Formation and Fertility amongst Immigrants from Pakistan and their Descendants in the United Kingdom: A Multichannel Sequence Analysis

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Harrison, J., Keenan, K., Sullivan, F., and Kulu, H. (2023). Union formation and fertility amongst immigrants from Pakistan and their descendants in the United Kingdom: A multichannel sequence analysis. *Demographic Research* 48(10):271–320. doi:10.4054/DemRes.2023.48.10.

BACKGROUND: Previous work identifies conservative family behaviour amongst Pakistanis in the United Kingdom relative to natives, including earlier marriage, fewer dissolutions, and higher fertility. However, few studies have investigated how fertility and partnership are intertwined and interdependent.

OBJECTIVE: Our aims are, first to identify differences between the family trajectories of Pakistanis and natives. Second, to determine if patterns are consistent across immigrant generations. Finally, we aim to identify how family trajectories vary across birth cohorts and education levels.

METHODS: We apply multichannel sequence analysis (MCSA) to data from the UK Household Longitudinal Study. We first use clustering methods to group similar individuals and then apply multinomial logistic regression to calculate the probability of belonging to a cluster based on individual characteristics.

RESULTS: The Pakistani population exhibits a higher likelihood of entering a direct marriage and having large families compared to natives. Cohabitation is rare amongst Pakistani population. These patterns have changed little between immigrant generations. Degree level education is associated with a higher likelihood of adopting behaviours typical to ancestral natives, however, the effects are not large enough to indicate convergence.

CONTRIBUTION: We demonstrate the need to investigate partnership and fertility trajectories simultaneously and show the value of multichannel sequence analysis for identifying differences between migrant groups. The results improve our understanding of family formation patterns of Pakistani immigrants and their descendants in the United Kingdom.

4.1. Introduction

Family processes and fertility are key metrics for measuring the acculturation and assimilation of immigrant minority groups (Glick, 2010; Lichter *et al.*, 2012; Kulu and González-Ferrer, 2014; Van Hook and Glick, 2020). The study of the Pakistani minority in the UK is increasingly important since they are one of the fastest growing ethnic groups in the United Kingdom (Rees *et al.*, 2012). Today the UK's Pakistani population, of approximately one million individuals, is the second largest non-white ethnic group, around half are born in Pakistan and half are British born with at least one Pakistan born parent (Office for National Statistics, 2020). The study of large immigrant groups and the identification of changes in their family behaviours between generations is pivotal to understanding and developing projections of the future population. Moreover, it can be an indicator for policymakers on the success of integration. For example, if we were to observe persistent differences in family processes between native and Pakistani groups, this would suggest segmented assimilation which might be occurring in other domains as well (Portes and Zhou, 1993).

Researchers continue to establish differences within South Asian immigrant populations in the UK and explore the heterogeneity of their life outcomes (Modood *et al.*, 1997; Dale and Ahmed, 2011), preferences (Berrington, 2020) and identity (Robinson, 2009). Pakistanis are found to be consistently disadvantaged socioeconomically with worse outcomes in labour market entry and income compared to both the White British majority and Indians, the other major South Asian population (Li and Heath, 2008, 2020; Khoudja and Platt, 2018).

Research on Pakistani immigrants has focussed on aspects of the life course in isolation including fertility patterns (Coleman and Dubuc, 2010; Kulu and Hannemann, 2016; Wilson and Kuha, 2018; Wilson, 2019), union formation and dissolution (Berrington, 1994, 2020; Hannemann and Kulu, 2015), health (Harding, 2003; Wild *et al.*, 2006, 2007) and labour market outcomes (Li and Heath, 2008; Heath and Di Stasio, 2019). However, we know that these domains are intertwined (Kulu and Milewski, 2007; Balbo, Billari and Mills, 2013). As such, whilst the literature involving Pakistani family formation and fertility in the UK context is growing, we still lack a holistic investigation of how they are intertwined and interdependent. The purpose of this study is to identify

differences in the ordering and tempo of family processes between natives and Pakistanis, to increase our knowledge of assimilation processes in Pakistani family processes in the UK.

While previous research has investigated the union formation and fertility of the Pakistani population separately, few have studied the trajectories simultaneously. Those that have, have applied sequence analysis techniques to the period of time around migration, and not the entire life course (Mikolai and Kulu, 2022a) or have used multistate event history models (Mikolai and Kulu, 2022c). We build upon on the research of Mikolai and Kulu (2022b), who like us use data from the United Kingdom Household Longitudinal Study (UKHLS). Our focus is specifically on differences between the Pakistani group and the native majority, and we include both men and women. Our analytical strategy applies multichannel sequence analysis (MCSA) to a sample of Pakistani immigrants, their descendants, and ancestral natives (a UK born group with two UK born parents) for a twenty-year period from ages 15 to 35. This differs from multistate event history models, as we do not measure rates of entry into specific states, rather we consider the entire early adult life course and create clusters of typical family formation trajectories.

This approach enables us to address the following research questions. First, how do the family trajectories differ between the ancestral native population and that of the Pakistani minority? Second, how similar are the trajectories between Pakistani immigrants and their descendants? Third, how have the trajectories of Pakistanis changed by birth cohort? Lastly, how does an individual's education level shape family trajectories of the Pakistani population?

4.2. Background

4.2.1. Changing family dynamics

Western Europe has witnessed de-standardisation of individuals' life courses (Ferrari and Pailhé, 2017). These changes reflect what is referred to as a Second Demographic Transition (Van De Kaa, 1987; Lesthaeghe, 1995) where delayed childbearing and cohabitation have become common, related to an increased desire for autonomy and self-actualisation at the expense of traditional family values. Further, it is argued that

with rising empowerment in both the education and economy of women, voluntary childlessness becomes increasingly acceptable by society (Lesthaeghe, 2014). Evidence from the United Kingdom supports this behavioural shift, more children are born outside of marriages, to both cohabiting parents and to lone mothers than ever before (Perelli-Harris *et al.*, 2010; Thomson, 2014) and cohabitation rather than direct marriages has become common (Beaujouan and Ní Bhrolcháin, 2011; Pelikh, Mikolai and Kulu, 2022). Whilst most cohabitations do convert to marriages eventually, cohabitating unions are more prone to dissolution compared to marriages (Wilson and Stuchbury, 2010; Beaujouan and Ní Bhrolcháin, 2011). The extent of these de-standardised behaviours can be related to early life experience and intergenerational transmissions of preferences (Liefbroer and Elzinga, 2012). But prevalence of these patterns vary across gender (Pelikh, Mikolai and Kulu, 2022), education (Mikolai, Berrington and Perelli-Harris, 2018), immigrant background, and over time.

4.2.2. Migrant and minority family formation

Across Europe and other Western countries differences between family patterns of natives and immigrant generations have been observed between destinations and between origins within countries (Hannemann *et al.*, 2020). What is clear is that societal changes relating to family formation are not necessarily consistent across immigrant and minority groups (de Valk and Liefbroer, 2007). There are contextual differences between origin and destination countries relating to policy and cultural differences in values and preferences, which influence both union formation and fertility. Whilst measurement of culture is difficult, general cultural proximity of a migrant's origin to the dominant native culture seems to correlate with behaviours more typical of natives, as studies in France (Pailhé, 2015), Sweden (Andersson, Obućina and Scott, 2015) and the United Kingdom (Hannemann and Kulu, 2015; Mikolai and Kulu, 2022c) suggest. Several theories exist which attempt to explain immigrant native differentials, these can apply to both union formation and fertility due to their intertwined nature (Rahnu *et al.*, 2015). Please see these prior studies for detailed overviews (Kulu, 2005; Milewski, 2010a; Kulu and González-Ferrer, 2014; Wilson, 2015).

Selection into migration is a central hypothesis underpinning research on migrants and their descendants. Those who migrate differ from those who remain in the country of

origin, typically being younger, in better health and with higher human capital (Borjas, 1987; Chiswick, 1999; Chiswick, Lee and Miller, 2008). The effects of social selection can contribute to observed migrant fertility being higher than natives, or mean a closer alignment with native levels (Kahn, 1988). The selection processes affecting Pakistani immigration to the UK has changed over time (Luthra and Platt, 2017). Earlier waves in the 1950's and 1960's were related to specific labour shortages, leading to low skilled men being predominant (Shaw, 2000). These men arrived as temporary migrants, however many remained resulting in the subsequent immigration of wives and children (Dahya, 1972). Whilst family reunification does remain important in more recent immigration during the 1990's and later, there is stronger positive socioeconomic selection; often comprising of young Pakistanis moving for study and work purposes (Larsen and Di Stasio, 2021). Thus, more recent immigrants – in terms of their fertility and family building preferences and patterns- may more closely approximate native patterns, having lower fertility and later transitions than those in their native Pakistan (Gangadharan and Maitra, 2003).

S*ocialisation* theory posits that early age experiences shape the preferences which determine future outcomes (Goldberg, 1959; Andersson, 2004; Toulemon, 2004; Milewski, 2010b; Dubuc, 2012). In Pakistan the fertility transition occurred later (Sathar and Casterline, 1998; Sathar and Framurz Kiani, 1999), with those born there exposed to cultural norms of larger families, earlier and more often direct marriage (when compared to UK native levels). This theory therefore suggests the timing of migration through the life course is crucial for understanding differentials between Pakistanis and ancestral natives. On one hand, migration after spending the early years in Pakistan may mean that, even after decades in the UK, Pakistani family norms prevail. On the other hand, migration to the UK during the 'sensitive period' of childhood/adolescence, and subsequent early life exposure to education institutions and residential contexts, which expose them to native norms, may mean Pakistani family behaviours converge more with UK ancestral natives (Adserà *et al.*, 2012).

A third explanation for migrant/native disparities (complementary to the second) posits that segmented assimilation (Portes and Zhou, 1993) can lead certain groups to become a *minority subculture* which can explain high fertility and early marriage behaviour amongst some groups of migrant descendants (Kulu *et al.*, 2019). The UK's historical

migration patterns have resulted in residential segregation of some ethnic groups, including Pakistanis (Peach, 1998, 2006). This segregation means socialisation for the second generation at early ages remains primarily with others of the same origin; if cultural value is placed on large families, these preferences are intergenerationally transmitted (Booth and Kee, 2009; Zorlu and Mulder, 2010; Lichter *et al.*, 2012; Wilson and Kuha, 2018). In the United Kingdom the Pakistani population report preferences for large families across multiple generations (Kulu and Hannemann, 2016), and this is associated with experiences of residential segregation (Wilson and Kuha, 2018).

A contrasting process of immigrant *adaptation* suggests that that over time behaviour alters to converge with the majority native population regardless of the context of early life socialisation (Gordon, 1964; Goldstein and Goldstein, 1981; Lee and Farber, 1985; Kahn, 1988; Ford, 1990; Milewski, 2007). This adaptation is related to experiences in other domains of the life course such as labour market success (Lundström and Andersson, 2012; Dupray and Pailhé, 2018), education (Dubuc, 2012, 2018), and housing (Kulu, 2005), which shape norms and decision-making. This also implies that those who migrate earlier in the life course would be more likely to exhibit 'native like' family behaviours as they have longer for this adaptation process to take effect (Ford, 1990; Adserà *et al.*, 2012). This may be a less salient explanation for Pakistani family behaviours in the UK, because the continued socioeconomic deprivation (Li and Heath, 2020) and housing disadvantage (Shankley and Finney, 2020) experienced by Pakistanis (relative to UK natives) suggests that adaptive processes in other domains have not materialised. However, it may be important for understanding behaviours in subgroups: for example, more educated Pakistani women display more 'native like' family behaviours than less educated Pakistanis (Dale and Ahmed, 2011; Dubuc, 2018).

Disruption is another theory relating to migrant families, where the economic and time investments associated with migration lead to postponement of family formation (Bean *et al.*, 1984; Hervitz, 1985; Mayer and Riphahn, 2000; Milewski, 2007, 2010a). Migration can be a cause of temporary separation from partners which creates a barrier to fertility. However, these disruptions may only temporarily cause changes in tempo not quantum (Ford, 1990). Disruption highlights the *interrelation of life-events* (Milewski, 2007, 2010a; Mussino and Strozza, 2012) a final theory of migrant family dynamics. Migration and mobility are responses to both individual circumstances and

changes in those circumstances. Hence why it is important to consider the interplay of multiple life course domains. Given the migration flows of Pakistanis to the UK, disruption could be a factor in family formation amongst the oldest immigrants. Among recent Pakistani arrivals, family formation and reunification is commonly given as a reason for migration, hence elevated fertility being observed around the time of arrival (Robards and Berrington, 2016).

4.2.3. Pakistani families in the United Kingdom

Previous research on family dynamics of Pakistanis in the United Kingdom finds that most enter direct marriages and have low divorce rates (Hannemann and Kulu, 2015). Typically, the transition into unions takes place at earlier ages compared to natives (Berrington, 1994). Overwhelmingly, unions are formed with members of the same origin and this has only decreased slightly amongst younger birth cohorts (Kulu and Hannemann, 2019). Many immigrants arrive having already married in Pakistan and although the second-generation do experience looser ties to Pakistan (Dale and Ahmed, 2011), even amongst them over half have spouses who arrived in the UK as adults (Georgiadis and Manning, 2011). This suggests that socialisation and the minority subculture hypothesis are important explanations for family behaviour.

Qualitative research, on the cohorts covered in this study, finds that the prospect of arranged transnational marriages were considered as a way for many young Pakistanis to appease family in Pakistan and the UK (Shaw and Charsley, 2006). Research suggests this family pressure is diminishing, and freer choice is emerging (Charsley and Bolognani, 2021), however less relevant since these birth cohorts are not observed in this analysis. Recent research on second generation Pakistanis suggests that they still maintain the expectations of direct marriage, albeit delayed compared to earlier birth cohorts, in contrast to ancestral natives who anticipate entering cohabitations for longer periods of time (Berrington, 2020). Later marriage and smaller families in Pakistani women is related to them having higher education (Dale and Ahmed, 2011; Dubuc, 2018) demonstrating that adaptation can be context specific. This postponement may not be down to personal choice, but rather an inability to find a partner due to being perceived as *'over-qualified'* or *'too old'* (Ahmad, 2012). Unions formed by Pakistanis are observed to be stable with low divorce and remarriage (Hannemann and Kulu 2015),

yet we recognise that this does not necessarily mean marriages are of better quality. Specific norms may alter the acceptability of divorce and the ease of obtaining one (Qureshi, Charsley and Shaw, 2014). Long-term separation is often negotiated by Pakistani couples in place of a formal divorce (Qureshi, Charsley and Shaw, 2014) thus avoiding the stigmatisation of being divorced (Qureshi, 2016) but ultimately meaning data sources do not reflect dissolution.

Fertility amongst the Pakistani group is high compared to both other minority groups and natives (Berrington, 1994; Dubuc, 2012; Wilson, 2015, 2019; Kulu and Hannemann, 2016; Kulu *et al.*, 2017). Although fertility has fallen, total fertility rate (TFR) amongst the British-Pakistani population fell from almost 5.0 in the 1970s to approximately 3.0 in 1997 (Coleman and Dubuc, 2010). Similarly, the number of children per household of this group fell in the last decade of the 20th century from 2.35 to 1.72 (Catney and Simpson, 2014). Still transitions to higher order births remain far more common amongst Pakistani women, including UK born, compared to ancestral natives (Kulu and Hannemann, 2016; Kulu *et al.*, 2017). For those who arrive as children, evidence shows that an earlier arrival results in childbearing behaviour more alike that of ancestral natives (Adserà *et al.*, 2012). However, Adserà and colleagues do not isolate Pakistanis specifically and homogenise them amongst a South Asian group.

Fertility remains elevated for the second generation, compared to ancestral natives, with mean completed fertility of around 3.0 for Pakistanis and Bangladeshis combined (Wilson, 2019), although there is evidence of some convergence (Georgiadis and Manning, 2011). This population level convergence can be a result of averaging divergent subpopulations within the second generation; where early family formation and large families is one option and childlessness another (Kulu *et al.*, 2019). Divergence is visible across education levels with high education increasing amongst the second-generation associated with lower fertility (Dubuc, 2018). Childlessness as a preference is not observed amongst the Pakistani second generation; younger generations expect to become parents at some point in time (Berrington, 2020), and their ideal family sizes are larger than natives (Penn and Lambert, 2002). These potential divergences are interrelated to divergences in education and socioeconomic status and can materially affect knowledge and use of contraception (Hennink, Diamond and Cooper, 1999). Pakistani born women in the UK on average have lower education

compared to Indian women (Dale *et al.*, 2002) and are more likely to fall into the non-professional group that Hennink and colleagues describe as using contraceptives less often. However, changes in selection processes of Pakistani immigrants likely mean that more recent, younger arrivals are better educated, (Luthra and Platt, 2017; Larsen and Di Stasio, 2021) and thus more likely to use contraception.

4.3. Hypotheses

Based on previous research we expect to find Pakistani first-generation immigrants to exhibit more conservative trajectories compared to natives, with early transitions into marriage and larger number of children due to their socialisation in Pakistan (H1). For the second generation, under the adaptation hypothesis trajectories should be more aligned with natives, although not necessarily converged (H2a). The socialisation and minority subculture hypothesis would be supported if there is a persistence of conservative trajectories between the first and second generation (H2b). Although, given that we do not observe how individuals have been socialised in their formative years, there could be support for socialisation even if the second generation have converged to behaviours akin to natives.

Since selection into migration has changed over time, we expect to see temporal and cohort differences in Pakistani trajectories, with later born Pakistanis expected to be more recent positively selected migrants and thus, more likely to postpone transitions (H3). Finally, Second Demographic Transition theory would suggest that education will act as a moderator, making more educated Pakistani groups more likely to display postponement behaviours and have less standardised trajectories, aligning them to the ancestral native population (H4).

4.4. Data and sample

The data used comes from the first ten waves of Understanding Society/United Kingdom Household Longitudinal Study collected between 2009 and 2019 (University of Essex Institute for Social and Economic Research, 2021). This dataset has retrospective fertility and partnership histories for all adult members of the sample, regardless of how many waves they appear in. Sample members are asked for

retrospective histories at the time they are first interviewed, and this is updated using subsequent waves.

4.4.1. Sample

For this study we follow people for twenty years from age 15 to 35. We restrict the sample to those born between 1950 and 1979, including only ancestral natives or members of the Pakistani minority community. Ancestral natives were identified as those who were born in the United Kingdom with two British born parents. For the Pakistani group, second generation was defined as those born in the United Kingdom with a father born in Pakistan. For those without information relating to the father a Pakistani born mother was used. Instances of intermarriage between ancestral natives and Pakistani-born are still low among observed cohorts (Kulu and Hannemann, 2019) with the risk of exogamous marriage for both Pakistanis and their descendants at less than one per 1000 person years. Therefore, bias stemming from prioritising father's place of birth is unlikely. To increase sample numbers for those who lacked information on parental country of birth self-reported ethnicity was used. Those who reported their ethnicity as White British were deemed ancestral natives providing, they were born in the UK. Those who migrated to the UK at some point and reported their ethnicity as Pakistani were assumed to be born in Pakistan and first-generation immigrants. Similarly, those born in the UK who defined their ethnicity as Pakistani were assumed to be of the second generation. Theoretically, those defined through this imputation could be grandchildren of immigrants or the third generation; however, given the migration history from Pakistan to the United Kingdom the likelihood of a third-generation individual being born prior to 1980 is low. Complete histories were gathered for 22,067 individuals. Five were dropped due to ambiguous gender, leaving a final sample of 22,062.

4.4.2. Descriptive statistics

Table 4.1 shows the sample descriptive statistics. We see a higher proportion of women in the native sample with the reverse amongst the Pakistanis. Birth cohorts are slightly skewed towards earlier cohorts for natives primarily due to the survey design. Older members of the sample only require one appearance at any wave to secure enough retrospective information for entry into the final sample, whereas for younger members,

born in the 1970s, multiple survey appearances are required therefore fewer from those cohorts make the final sample. Second-generation Pakistanis are skewed towards later birth cohorts, which is expected given the migration history of Pakistanis to the UK. The first-generation are also skewed towards younger ages, we emphasise that this group combines different selection mechanisms including child arrivals who migrated with parents soon after their birth and recent adult arrivals (Luthra and Platt, 2017).

Education levels are similar for natives and British-born Pakistanis, with first generation immigrants reporting lower educational attainment than both. The Pakistani born had a relatively sizeable proportion with missing data for qualification obtained (approximately 14%); thus, we have imputed the qualification achieved, based on a combination of school leaving age, further education leaving age, and school attendance information. We coded those who left education before age 15 or never attended school as 'no qualifications', those who left school or further education at age 15 or 16 have GCSE level or equivalent, those leaving between 17 and 20 have A-Level or equivalent and, those with education leaving ages of 21 and above have degree level education. We retain a missing category for those with no information about qualifications obtained, school attendance or school leaving, in total less than 1% of the sample. We accept while there may be minor misclassification (e.g., individuals can leave education without obtaining any qualifications), the trade-off is a larger sample to work with. For robustness we repeated the analysis with a larger missing category (i.e., without this imputation process) and the substantive message of the results do not change. We anticipate that education levels will differ by gender (Khattab and Modood, 2018), therefore gender stratified education statistics are presented in Appendix Tables A1 and A2.

Table 4.1 - Descriptive statistics of full sample

	Native	2nd Generation	1st Generation	Total
Gender: %				
Male	46	51	51	46
Female	54	49	49	54
Cohort: %				
1950 - 1959	33	4	24	32
1960 - 1969	39	27	34	39
1970 - 1979	28	70	42	29
Highest Qualification: %				
Degree or Equivalent	33	33	22	32
A Level or Equivalent	30	1	3	19
GCSE or Equivalent	19	16	15	18
Other Qualifications	9	6	11	9
No Qualifications	9	11	30	10
Missing	0.1	0.3	1	0.2
Total: N	20848	256	958	22062

Source: Authors own calculations, based on UKHLS

4.5. Methodology

4.5.1. Sequence analysis and optimal matching

Sequence analysis allows for the consideration and ordering of life events, adding dynamic context to life course analysis that cross sectional measures lack (Abbott, 1995). The benefit is that it allows for the study of life course complexities as they take place (Aassve, Billari and Piccarreta, 2007). Over time, sequence analysis has increasingly been used to model multiple domains of the life course in a process called multichannel sequence analysis (MCSA). MCSA has some notable advantages over single channel analysis; firstly, it avoids the need for widespread recoding and combining of multiple trajectories (Gauthier *et al.*, 2010) and secondly, allows for a more holistic overview of the life course trajectories taking into consideration multiple variables over time (Pollock, 2007).

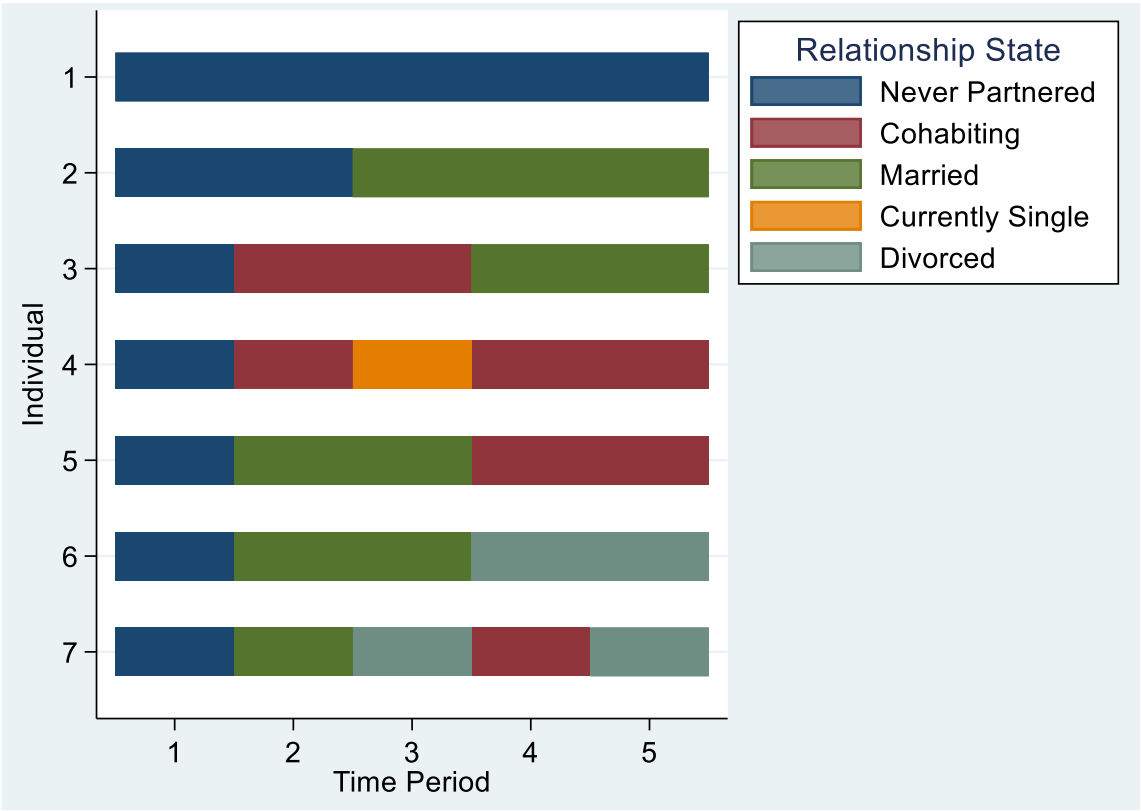
In this study sequences were created across two domains, one showing the partnership state of individuals and the other their childbearing. Individuals were observed monthly from age 15 to 35 meaning 240 states for each sequence was recorded. The relationship

trajectory was described using six categories*, 'Never Partnered', 'Cohabiting', 'Married'*[1]*, 'Divorced', 'Widowed', and 'Currently Single'*. Currently single are defined as those who have only been in cohabiting unions previously but are not currently in one. We consider it important to distinguish between those with experience of marital and cohabitation dissolution due to the differing characteristics that determine entry (Perelli-Harris *et al.*, 2010) and exit (Lampard, 2014) of such unions.

The partnership trajectories could move in a variety of ways as illustrated in Figure 4.1. Individual 1 remains in a never partnered state throughout observation. Individual 2 enters a direct marriage, individual 3 enters a cohabiting union which then transitions to marriage. Individual 4 cohabits, dissolves that union, becoming *"currently single"*, then re-enters a cohabiting state. Individual 5 is a specific case, whereby their marriage dissolves during time-period three and immediately afterwards they enter a cohabiting union thus failing to register a period of divorce. This is a possible cause of underestimation of divorce in the sample, however this exact scenario is rare, less than 1% experience this direct transition in our sample (all except one being ancestral natives). Individual 6 marries and then becomes divorced. Whilst individual 7, experiences a marriage then divorce, a period of cohabitation and once that cohabitation dissolves, returns to divorced. The rationale behind this process is to ensure that previous experiences which may stigmatise the individual are considered. Again, this scenario is only experienced by 1% of the sample (all natives) given the relatively short period of the life course that we observe.

[1] Married includes civil partnerships

Figure 4.1 - Examples of relationship sequences



Fertility trajectories were coded as a count of children ever born with six states in total from 'childless' to 'five children or more'. The number of children could therefore only increase over time. For multiple births, the parent moves directly from childless to two children, for example. Mortality of children was not considered. Table 4.2 shows the percentage who ever experienced each of the states described above, by immigrant background. Most do transition into a married state across the observation period. Experiencing cohabitation, currently single and divorce is more common among natives, the rarest relationship transitions are entries into widowhood. The transition to higher parities (especially parity 3 and above) is common amongst Pakistanis compared to natives (Kulu and Hannemann, 2016).

Table 4.2 - (Unweighted) Percentage ever experiencing each union and fertility state

	Native	2nd Generation	1st Generation	Total
Ever experience 'Union State': %				
Never Union	100	99	98	100
Cohabiting	48	10	1	46
Married	67	70	72	67
Currently Single	10	2	0.2	9
Divorced	17	11	4	16
Widow	0.4	0.4	1	0.4
Ever experience 'Fertility State': %				
Childlessness	100	100	100	100
One Child	61	71	78	62
Two Children	42	64	64	43
Three Children	14	45	44	16
Four Children	4	21	21	5
Five or more Children	1	10	8	1
Total: N	20848	256	958	22062

Source: Authors own calculations, based on UKHLS

The pair-wise difference between sequences is derived through a process of optimal matching which involves calculating the most efficient manner of converting one sequence into another using a combination of insertion, deletion (indel) and substitution when costs are assigned to each of these processes (Abbott and Forrest, 1986; Piccarreta and Lior, 2010). All unique sequences are compared to each other resulting in a dissimilarity matrix which defines the total distance between any pair of sequences. Using this matrix similar sequences can be identified and clustered.

There is much debate in sequence analysis research about how to assign these costs (Abbott and Tsay, 2000). Our substitution costs are derived from the transition rates between states generating two 6x6 substitution matrices, one for each domain, using the 'TraMineR' R package (Gabadinho *et al.*, 2011). Indel costs are set to one, which is seen as an increasingly standard method and used in similar studies (Aassve, Billari and Piccarreta, 2007; Piccarreta and Lior, 2010).

4.5.2. Clustering

To cluster the trajectories, we used agglomerative nesting also known as hierarchal clustering under Ward's method (Ward, 1963). Hierarchical clustering uses a

dissimilarity matrix created through optimal matching, initially all unique sequences are clustered individually and the two most similar merge into a larger cluster. At each fusion the within-group dispersion is minimised (Murtagh and Legendre, 2014). This proceeds until all sequences have been merged into one cluster containing all sequences. To cluster the data, we used the 'cluster' R package (Maechler *et al.*, 2021). We identified solutions from three clusters to nine clusters. This upper limit was chosen to avoid too much complexity when it comes to describing the typologies and ensure that there is sufficient membership in each cluster for multinomial modelling.

A quandary for researchers clustering data is that there is an element of subjectivity in the choice of total number of clusters (Piccarreta and Lior, 2010). The optimal number of clusters will "minimise within-cluster and maximise the between-cluster distance" (Mikolai and Lyons-Amos, 2017). Statistical measures do exist to guide this decision-making process, which are highlighted in the appendix (Table A3), but they often do not support the same solution. We use the WeightedCluster[2] package in R to calculate these indices; detailed mathematical descriptions of the indices can be found in the package manual (Studer, 2013).

The main body of the results will show a four-cluster solution. This was deemed optimal based on the Average Silhouette Width (Kaufman and Rousseeuw, 1990). The appendix (Table A4 and Figures A3 and A4) features supplementary analysis of the three-cluster solution which the Calinski-Harabasz index (Caliński and Harabasz, 1974) deemed optional. In general, different cluster solutions will yield little variation across the main groups (Aassve, Billari and Piccarreta, 2007). Other measures highlighted larger cluster numbers as optimal. However, fewer clusters highlighted heterogeneity between clusters better and maintained sample size for subsequent modelling. Using more clusters resulted in the differences observed between the clusters becoming of little substantive value.

4.5.3. Multinomial logistic regression

Sequence and cluster analysis are merely descriptive methods for categorising data (Pollock, Antcliff and Ralphs, 2002). Therefore, we use a multinomial logistic

[2] For the avoidance of doubt whilst this package allows for weighted data, weights were not used in assigning cluster membership

regression (MLR) to calculate the likelihood of belonging to each of the clusters. Results are presented in the form of average marginal effects due to the relative ease of interpretation (Ferrari and Pailhé, 2017) compared to a relative risk ratio where one of the clusters must be the baseline risk.

The dependent variable is the identified cluster with independent variables; immigrant background, gender, ten-year birth cohort and highest education ever reported. We apply cross-sectional weights to the analysis and adjust standard errors to account for the clustering of respondents at household level (Mikolai and Kulu, 2022c), and the use of ethnic minority boosts in the UKHLS. For robustness we ran unweighted models, these models produce comparable results for the differences between migrant generations and natives.

4.5.4. Pakistani only subsample

Due to the dominance of natives in the sample we expect clusters to be determined by the behaviours of the native population. While this allows for analysis of differences between the immigrant populations and the majority population, it hides the heterogeneity within the Pakistani group. Therefore, additional analysis will repeat the above methods with a sample restricted to only the Pakistani born and their descendants.

For consistency we again show the four-cluster solution in the main results, with the three-cluster solution in the appendix (Table A5, Figures A5 and A6). To avoid zero cells some minor changes were made, notably the combining widowed and divorced, and top coding fertility at ‘four or more children’. As Table 4.2 shows, the prevalence of widowhood before age 35 is low, thus a transition to that state is unlikely to be a defining characteristic of cluster membership.

4.6. Results

4.6.1. Four cluster solution

The four-cluster solution broken down by immigrant generation is presented in Table 4.3. The four clusters identified can be characterised as:

(1) Later transitions and later (or no) childbearing; (2) Cohabitors; (3) Long-term single and childless, and (4) Direct marriage, large families.

Figure 4.2 presents chronograms for each cluster (sequence index plots, which show individual sequences can be found in the appendix- Figures A1 and A2). We characterise cluster one, **'Later transitions and later (or no) childbearing'**; as a mixture of different union types but mostly resulting in marriage by age 35 with some cohabitation and dissolution. Childbearing is delayed with less than 50% transitioning to parenthood before age 35 and no fertility transitions before age 25. The second cluster is **'Cohabitors'**; this is the smallest cluster and is populated by those who enter a cohabitating relationship at some point with few of them transitioning to marriage. The unions formed appear less stable with fluctuations between cohabiting and currently single common. Transitions to childbearing are still common, all have at least one child by the end of the observation. Cluster three is **'Long term single and childless'**; containing primarily those that have no children and never enter any form of union. Those that do, do so late into the observation time. The final cluster is **'Direct marriage, and large families'**; this group primarily transitions directly from never union to married, almost all before age 25 and remain married until the end of the observation time. Fertility trajectories suggest a high parity reached. All have transitioned to childbearing by age 30 and multiple children is the norm.

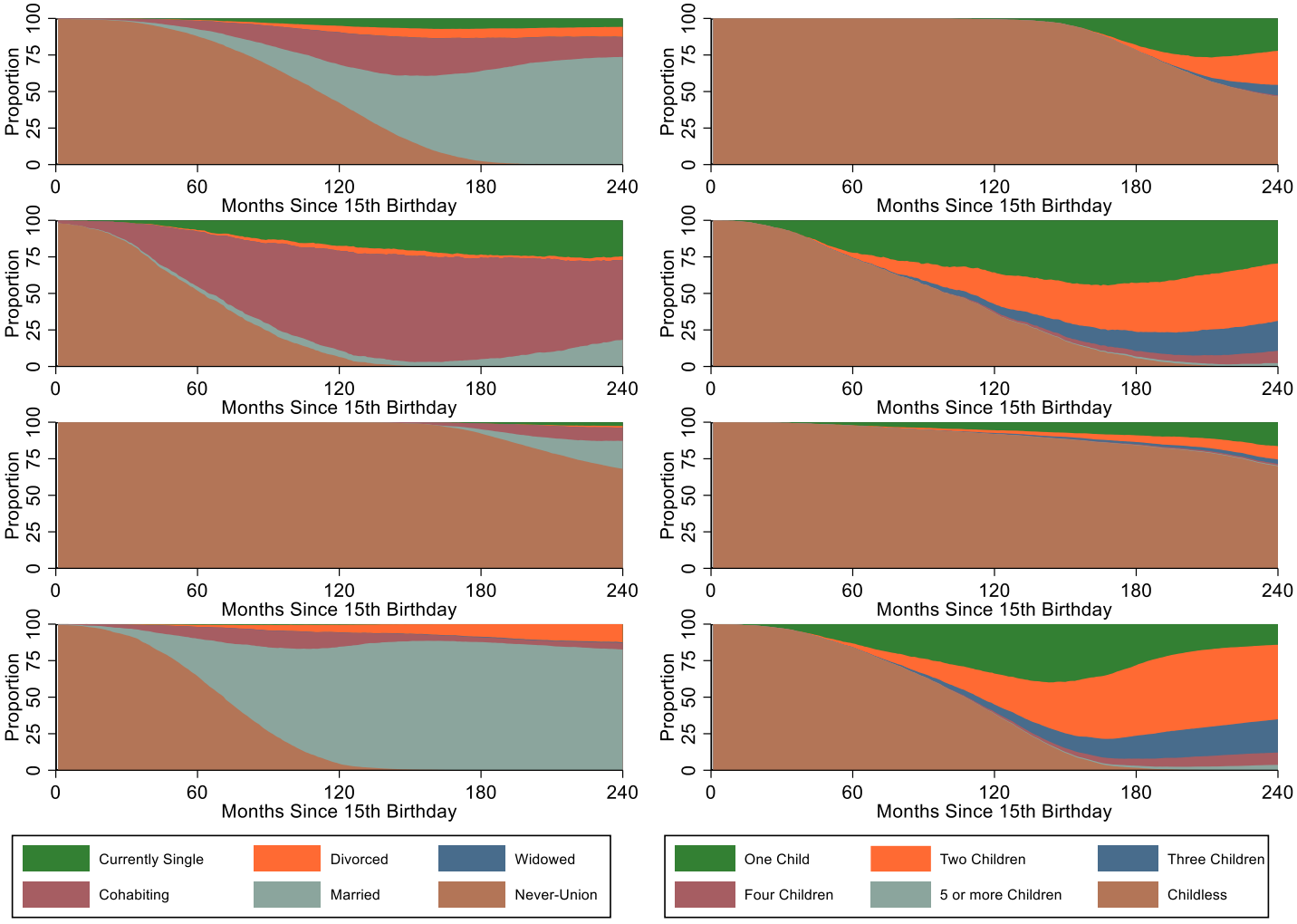
The breakdown by immigrant generation suggests increased likelihood of remaining long term single and childless or entering direct marriage and large families, for Pakistanis compared to natives. The cohabitors cluster is almost entirely populated by natives, only a handful of second-generation Pakistanis enter this trajectory and no Pakistani born individuals. Moreover, we see that later transitions and late childbearing is more common amongst natives than Pakistanis.

Table 4.3 - Cluster membership by immigrant generation, four-cluster solution (unweighted %)

Cluster	Native	2nd Generation	1st Generation	Total
Later transitions and later (or no) childbearing	37	21	23	37
Cohabitors	6	1	0	5
Long-term single & childless	28	34	35	29
Direct marriage, large families	29	44	41	29
Total: N	20848	256	958	22062

Source: Authors own calculations, based on UKHLS

Figure 4.2 - Chronogram of four cluster solution, whole sample



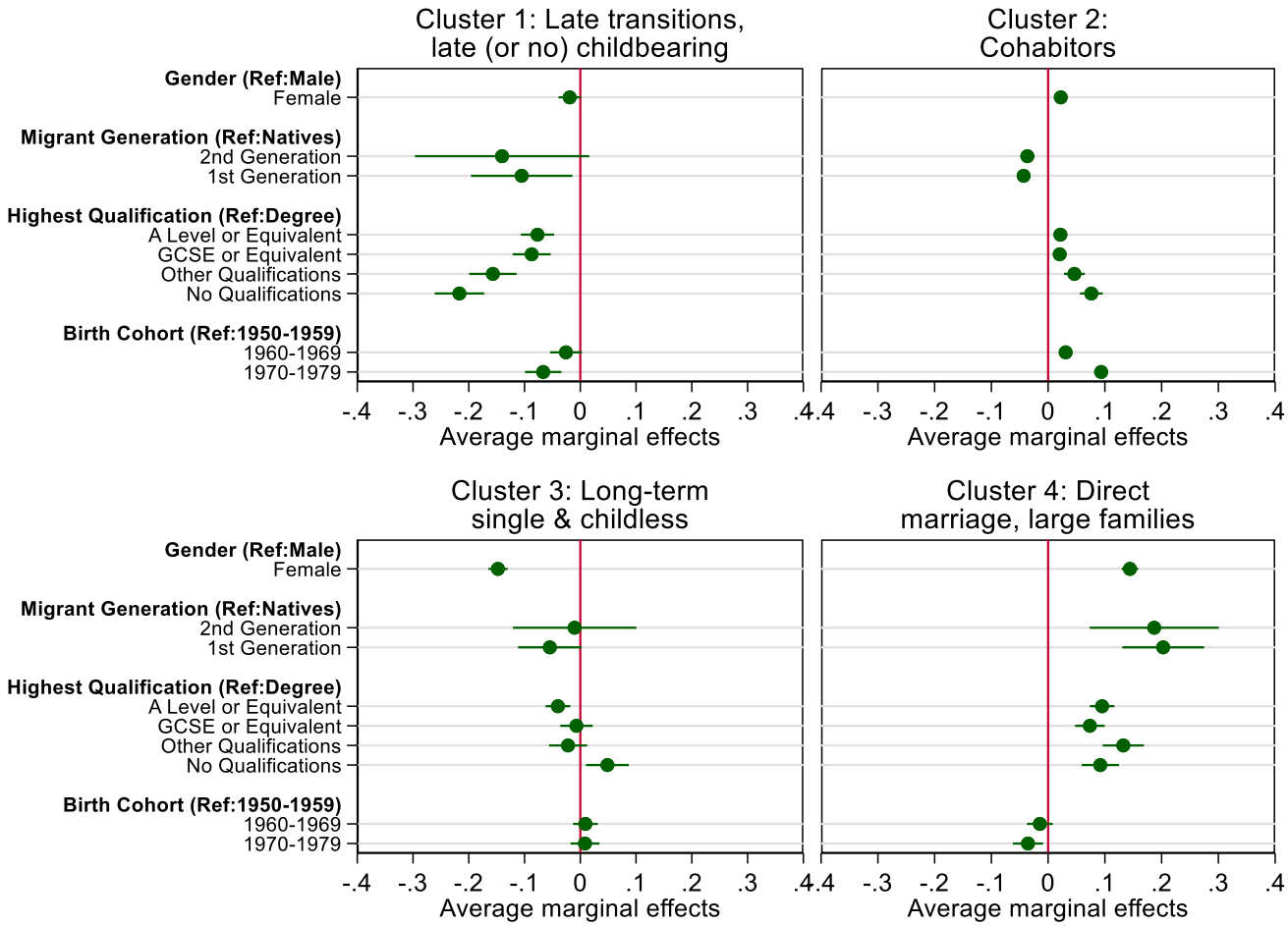
Notes:
1 Left relationship state. Right fertility state
2 Top to bottom cluster one to cluster four
Source: Authors own calculations, based on UKHLS

Figure 4.3 presents the average marginal effects of the MLR. This shows that compared to natives, Pakistanis of both generations have higher probabilities of entering **'Direct marriage, large family'** cluster. Moreover, they are less likely to belong to '**Later transitions and later (or no) childbearing'.** Cohabitation is also found to be less common among the Pakistani population; the marginal effects appear small due to it being an uncommon cluster for ancestral natives too.

The education gradient suggests that decreasing levels of education are associated with increased probability of engaging in cohabitation as an alternative to marriage. Similarly, later transitions and childbearing is associated with increasing education levels. Having no qualifications is associated with belonging to the long-term single and childless cluster. Women are less likely to be single and childless at 35 or to experience delayed transitions to unions and parenthood. This finding is expected given biological pressures on fertility and the general norm that women are younger than their partners (Gustafson and Fransson, 2015). Women are slightly more likely than men to be a member of the **'Cohabitator'** cluster.

Among later-born cohorts, the likelihood of being in the **'Direct marriage, large family'** trajectory is lower, and they are more likely to be in the **'Cohabitors'** cluster. The increase in cohabitation over time also results in decreased likelihood of having later transitions and delayed childbearing. The likelihood of belonging to the **'Long-term single and childless'** cluster did not vary significantly by birth cohort.

Figure 4.3 - Average marginal effects of four cluster membership - 95% CIs



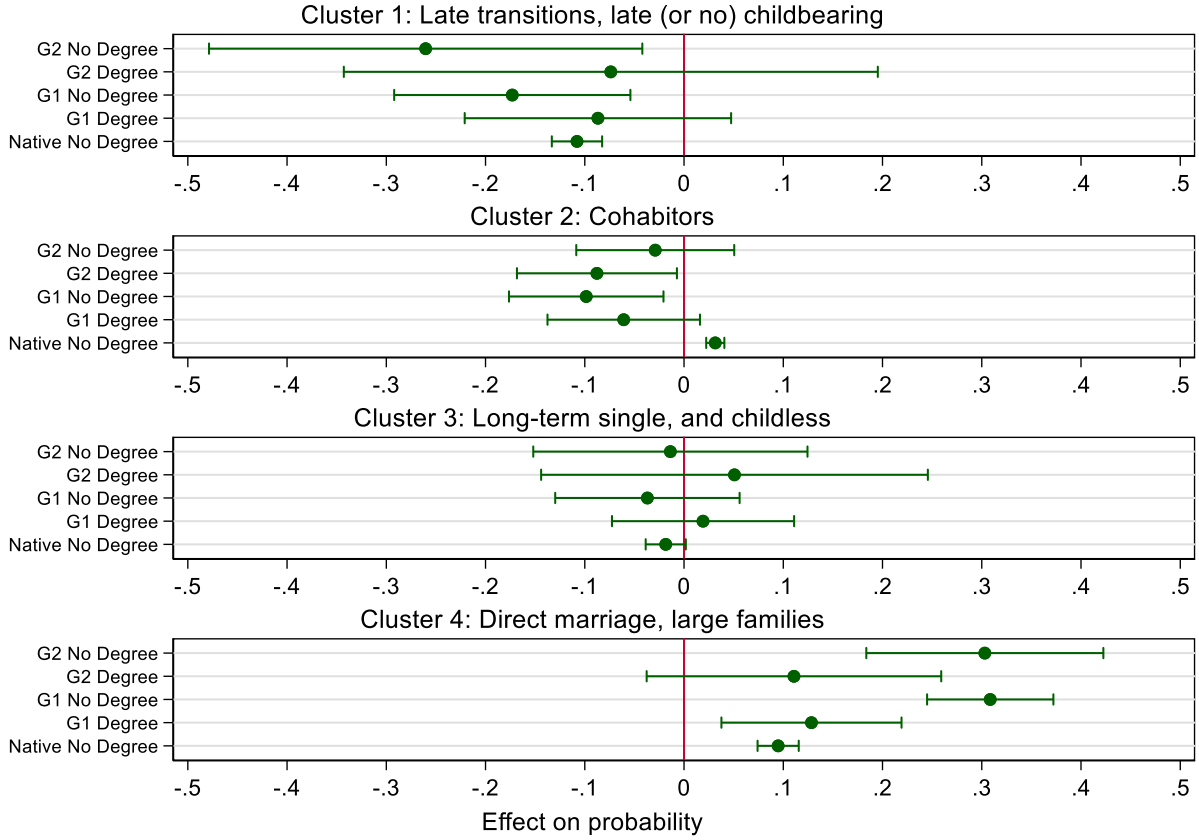
Notes:
1 Red line = 0 (no marginal effect).
2 Survey weighted.
Source: Authors own calculations, based on UKHLS

4.6.2. Interactions between migrant status and other characteristics

To study if the influence of immigrant generation differs by gender, birth cohort or education we used interactions of these variables. Likelihood ratio tests suggested that neither gender nor cohort interacted with migrant status led to improved model fit. We dichotomised the education variable to preserve observations within each interaction and found that degree versus no degree, interacted with migrant generation, did improve the model fit (albeit only at 90% significance level). Figure 4.4 shows the average marginal effects of these interactions, with the model controlled for cohort and gender.

The results show distinct differences between Pakistani immigrants who have a degree and those who do not. Those who have a degree are more aligned with the native group in terms of a reduced likelihood of belonging to the **'Direct marriage and large families'** trajectory and an increased likelihood of being in the **'Late transitions, late (or no) childbearing'** cluster. The **'Long-term single and childless'** and **'Cohabitor'** clusters see minimal variation for Pakistanis based on higher education.

Figure 4.4 - Average marginal effects of interaction between immigrant generation and having a degree on probability of cluster membership - 95% CIs



Notes:
1 Red line = 0 (no marginal effect).
2 Due to zero occurrence of cohabitors cluster in Pakistani population manual imputation of one observation was done.
3 Survey weighted.
Source: Authors own calculations, based on UKHLS

4.6.3. Pakistani only

The results from the full sample suggest a strong similarity between Pakistani born immigrants and British-born descendants. However, due to the high proportion of

natives in the sample there could be heterogeneity within the Pakistani group that is undetectable in the results. Thus, we restrict the sample to only Pakistanis allowing the clusters to be formed as a reflection of their trajectories.

We present a four-cluster solution again, with the three-cluster solution in the appendix (Table A5, Figures A5 and A6). Table 4.4 shows the percentage breakdown within each cluster and Figure 4.5 the chronograms which show the cluster make up visually. The four clusters can be defined as:

(1) Early marriage, large families, (2) Never partnered, (3) Later marriage, smaller families, (4) Early marriage, small families.

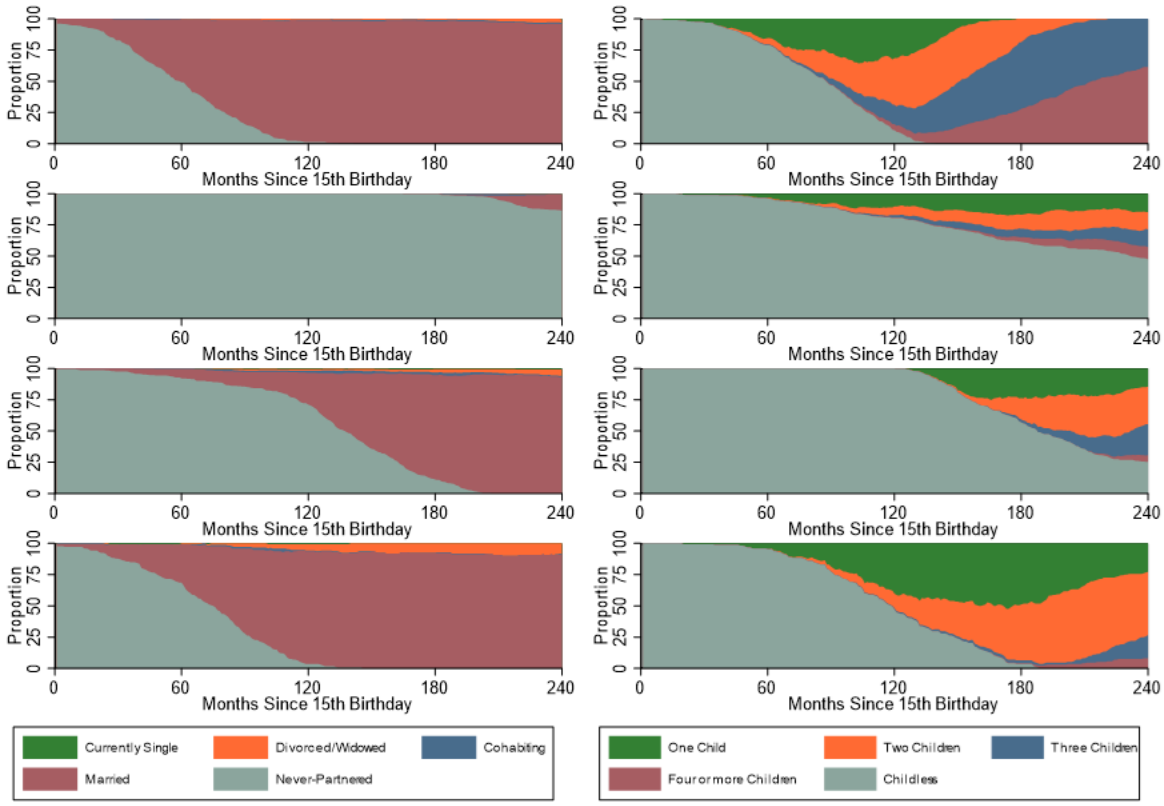
First, **"Early marriage, large families"** is a cluster where all individuals enter direct marriage before age 25 and all transition into having three or more children by the end of the observation period. Second, **"Never partnered"** where members remain in a never partnered state, although around half of these individuals do eventually transition into parenthood. Third, **"Later marriage, smaller families"** a cluster where direct marriage is still dominant, but the transitions do not take place until the late 20s, and where childbearing occurs at a much slower pace with lower parities compared to those in cluster one. Finally, **"Early marriage, small families"** a cluster with transitions to unions happen at a similar rate as cluster one but overall fertility is limited to one or two children. This cluster also features individuals who experience divorce and widowhood (although this is a negligible proportion).

Table 4.4 - Breakdown of cluster membership, Pakistani only sample (unweighted %)

Cluster	1st Generation	2nd Generation	Total
Early marriage, large families	25	27	26
Never partnered	32	32	32
Later marriage, smaller families	28	26	28
Early marriage, small families	14	15	14
Total	958	256	1214

Source: Authors own calculations, based on UKHLS

Figure 4.5 - Chronograms of the four-cluster solution, Pakistani only subsample



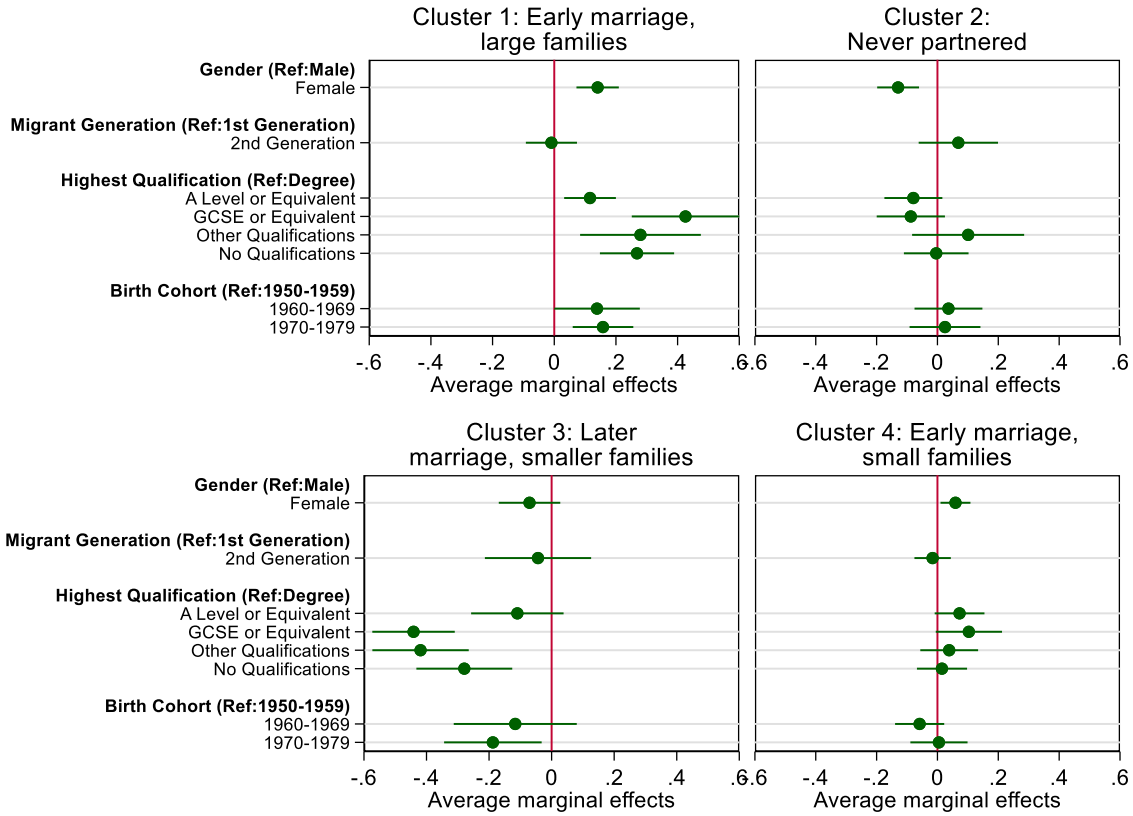
Notes:
1 Left relationship state. Right fertility state
2 Top to bottom cluster one to cluster four
Source: Authors own calculations, based on UKHLS

Figure 4.6 highlights limited differences between the first- and second-generation Pakistanis. Post 16 education (A-Level and higher) is associated with increased likelihood of having **'Later marriage, smaller families'**. Those who obtain lower qualifications are more likely to take a trajectory of **'Early marriage, large families'**. '**Early marriage, small families'** and **'Never partnered'** clusters do not show a clear gradient with education.

Gender effects indicate that women of Pakistani background are less likely to end up **'Never partnered'**, but there is seemingly little difference between men and women relating to the likelihood of entering clusters with smaller families, both early and late marriage. Women do have increasing likelihoods of entry into the '**Early marriage,**

large families' cluster, indicating that earlier transitions are more common amongst women. For cohort we also see little indication of change over time for the Pakistani group. There is some indication of more recent cohorts having increased likelihood of belonging to '**Early marriage, large families'** and a reduced probability of belonging to **'Later marriage, smaller families'.**

Figure 4.6 - Average marginal effects of four cluster membership, Pakistani only sample - 95% CIs



Note: Indel costs =1. Red line = 0 (no marginal effect)
Source: Authors own calculations, based on UKHLS

4.6.4. Robustness and sensitivity

Indel Costs: Decision making regarding the choice of indel and substitution costs in optimal matching can appear somewhat arbitrary, a commonly raised criticism of sequence analysis (Pollock, Antcliff and Ralphs, 2002). The choices made in our analysis are consistent with those in similar previous research see: (Aassve, Billari and Piccarreta, 2007; Piccarreta and Lior, 2010; Mikolai and Lyons-Amos, 2017; Delaporte and Kulu, 2022). However, substitution costs and indel costs are interrelated, which can alter the results of optimal matching and clustering (Bison, 2009). We repeated the

analysis with indel costs of 1.5 and 2 which have been used as sensitivity analyses in optimal matching (Mikolai and Lyons-Amos, 2017; Mikolai and Kulu, 2019). Both yielded comparable results to the analysis presented above where indel cost is 1 (see the appendix -Table A6 and Figures A7 and A8- for results where indel cost of 2). Interpretation and description of the clusters remain the same with minimal variation on membership. The main differences were that the association between lower education and belonging in the cohabitation cluster, and between first generation immigrants and belonging to the **"Later transitions smaller families"** cluster diminished. Nevertheless, the interpretation of the results that Pakistani life courses are more conservative and that differences between first and second generation are limited remains.

Child Migrants: In this sample around 25% of the Pakistani-born group arrived in the UK before the age of 15. Studies of immigrants take a variety of approaches when it comes to the categorisation of those who migrated as children, with differences in family dynamics found relating to age at arrival (Adserà *et al.*, 2012). Our approach took a strict definition that being born in Pakistan, regardless of age at migration, constituted a first-generation migrant. However, we accept that there could be nuance in this definition and those who migrate in childhood might be more culturally aligned with the second generation. We also know that the selection process into being a child arrival, or rather the selection factors of their parents, are different to adult immigrants from the same birth cohort (Luthra and Platt, 2017). As a sensitivity analysis we recategorised those first, as their own distinct group and second, combined with the second generation. Replicating the analysis using this sampling method found no substantive change in either the direction or the magnitude of the effects, only that the confidence interval estimates became wider due to reduced precision.

4.7. Discussion

This study extends previous analysis by Mikolai and Kulu (2022b) on immigrant/native differences in family behaviour in the UK. By focussing on the Pakistani group specifically, we find evidence for the persistence of conservative family formation patterns (direct marriage) compared to ancestral natives, supporting previous findings which have combined Pakistani and Bangladeshi populations (Berrington, 1994; Dubuc, 2012; Kulu and Hannemann, 2016; Wilson, 2019). There is limited evidence of changes

in fertility and partnership of Pakistanis across immigrant generations or birth cohorts, providing support for the minority subculture hypothesis and cultural entrenchment of behaviours (Wilson, 2020). In fact, we find evidence that more recent cohorts of Pakistanis display even more conservative behaviour, with those born after 1960 more likely to have a trajectory of '**Early marriage, large families'.** We attribute this to changes in the selection and the lack of disruption faced by younger cohorts whose partnership formation years are more likely to be spent in one location. Lastly, we find that higher education levels are associated with partial convergence to native family building patterns implying that there is a relationship between processes of adaptation, socialisation, and education institutions.

Our first aim was to identify differences between Pakistanis and the ancestral natives. We find similarities in the likelihood of being single and childless by age 35 between natives and Pakistanis. This supports the idea that union formation and childbearing, some time before age 35 is a norm for both groups. In the full sample, most Pakistanis are in the **'Long-term single and childless'** or **'Early transition with large families'** cluster. Implying that the elevated fertility found in this group is associated with higher parity transitions and not a consistent increase across all Pakistanis, which has been alluded to in previous research (Kulu *et al.*, 2017). Amongst natives there are changes consistent with the Second Demographic Transition (Van De Kaa, 1987; Lesthaeghe, 1995), increased likelihood of cohabitation as an alternative to marriage is strongly associated with later birth cohorts, but there is no evidence that this has occurred for Pakistanis, almost none of whom experience cohabitation for long periods of time. Overall, the differences observed between natives and Pakistanis provide support for *Hypothesis 1*.

The second research question was to identify differences between the Pakistani immigrant generation and their descendants. We find limited evidence of assimilation through generations, therefore accepting *Hypothesis 2b* supporting an existence of a minority subculture and within group socialisation being dominant (Lichter *et al.*, 2012; Kulu *et al.*, 2019). Speculatively we believe this can be related to wider issues such as residential segregation faced by the group (Peach, 2006), this segregation inhibits socialisation with the majority and so preferences for large families become culturally entrenched (Wilson and Kuha, 2018; Wilson, 2019). Previous research has suggested

that fertility has reduced from first to second generation (Kulu and Hannemann, 2016) but results here counter this. The use of a more holistic approach such as MCSA, finds relative consistency in the distribution of family trajectories between generations. These results could be considered a sign of disadvantage, however, it is important to emphasise that the cultural preferences that seem to be transmitted between generations do not necessarily reflect disadvantage in the same way it does in the majority population (Robson and Berthoud, 2006).

Despite limited assimilation between generations, the analysis does reveal that there is heterogeneity within the Pakistani group overall. The clusters which emerge from analysis of the Pakistani subpopulation clearly demonstrate differences in the tempo of life events such as union formation and childbearing. Moreover, there is a sizeable proportion who remain **'Never partnered'**. The second demographic transition (Van De Kaa, 1987; Lesthaeghe, 1995) suggests that this becomes increasingly common over time, although membership of this cluster is not apparently associated with birth cohort. Even within this cluster more evidence of heterogeneity can be found with many transitioning to parenthood, whilst unpartnered. We considered if this could be a data error, yet others have explored this data and find no reason to suspect this (Mikolai and Kulu, 2022c). UK census results also find around 8.8% Pakistani households are 'lone parent with children'[3] (Office for National Statistics, 2019a). We offer two explanations, first instances of couples living apart, possibly one remaining in Pakistan; second, non-standard family trajectories existing in the UK Pakistani population, that previous research has not sufficiently identified.

Our third research question was interested in the differences over time. Whilst differences between generations are not clearly identifiable, there are differences between birth cohorts in the Pakistani subsample. '**Early marriage, large families'** is associated with more recent birth cohorts and the converse true with reduced likelihood of belonging to **'Later marriage, smaller families'** for younger members of the sample, this thereby counters what we proposed in *Hypothesis 3*. We believe this is an effect of different selection regimes and the changing make-up of the Pakistani population over time (Luthra and Platt, 2017). Older birth cohorts are primarily the

[3] The census category is not specific to never-partnered childbearing but shows that the resulting household composition is found.

immigrant generation who have experienced the disruptive effects of migration involving separation from spouses or entry to a new network (Bean *et al.*, 1984; Milewski, 2007). Conversely, more recent birth cohorts comprise of more child migrants who do not face that disruption. Even amongst adult arrivals born in the 1970's disruption is less of a factor as they are primarily either migrating to form a union (Georgiadis and Manning, 2011; Robards and Berrington, 2016) or positively selected and arrive with a spouse they married in Pakistan. We do acknowledge that there could be an unobserved catch-up period after age 35 (Ford, 1990), where those who face disruption eventually reach higher parities or form a union. Thus, we can consider only following individuals until age 35 as a limitation of this study.

Our final research question was about the influence of education. In the full sample, we see clear gradients of higher education being associated with increased likelihood of entering the **'Later transitions, late (or no) childbearing'** cluster a consequence of delayed transitions to union and fertility due to time spent in education (Billari, Hiekel and Liefbroer, 2019). When studying the Pakistani minority alone we see that education has little association with the likelihood of being **'Never partnered'** or having an **'Early marriage, small families'** trajectory. This implies that there is some element of personal preferences and choice of family structure that operates externally to education obtained. However, we still observe high education associated with increased likelihood of **'Later marriage, smaller families'**, and low education associated with **'Early marriage, large families**'.

We used interaction terms to see how the effect of degree level education varied between generations. We found that having a degree for both the immigrant generation and descendants was predictive of exhibiting distribution of life trajectories more like natives, ceteris paribus, supporting previous evidence (Dale and Ahmed, 2011; Dubuc, 2018). It increased likelihoods of belonging to **'Later transitions, late (or no) childbearing'** cluster and was negatively associated with a **'Direct marriage, large families**' trajectory, providing support for *Hypothesis 4*. Importantly, education alone is not a sufficient explanation of assimilation to native processes. The results reveal that even with degree level education Pakistani born individuals still have an increased likelihood of earlier marriage and childbearing than ancestral natives of any education level. Additional factors are at play, personal preferences related to culture,

socioeconomic factors, and education determine the life course and these operationalise differently between the Pakistani minority and the British majority.

There are some limitations in our study: First, highest qualification/education is endogenous to the family processes under study. We justify including it as a cross-sectional measure as necessary given data restraints. Future research should consider additional domains such as labour market participation (Mikolai and Kulu, 2022a). Second, we do not observe high rates of union dissolution; the unions we observe are relatively stable, however attrition in UKHLS is highly related to separation and subsequent mobility (Mitchell, Collins and Brown, 2015), leaving sequences incomplete.

Whilst we find evidence for higher fertility and earlier direct marriage as being typical trajectories of Pakistanis in the UK, we do find glimpses of heterogeneity that should continue to be explored, having been less studied in previous literature. To our knowledge this is the first application of MCSA on Pakistani life courses in the United Kingdom and we recommend that MCSA and approaches like multistate modelling (Mikolai and Kulu, 2022c) continue to be expanded and refined as they have much to offer in longitudinal research of migrants and their descendants.

5. All-cancer Incidence and Mortality in Pakistanis, Bangladeshis and their Descendants in England and Wales

An abbreviated version of this chapter has been published in BMC public health. Which can be cited as follows:

Harrison, J., Sullivan, F., Keenan, K., & Kulu, H. (2024). All-cancer incidence and mortality in Pakistanis, Bangladeshis, and their descendants in England and Wales. *BMC Public Health*, *24*(1), 3352. https://doi.org/10.1186/s12889-024-20813-1

BACKGROUND: This paper seeks to further understand health differentials between Pakistani and Bangladeshi immigrants, their descendants, and the native population in England and Wales. We choose to focus on cancer as one of the leading causes of morbidity and mortality in developed countries. Previous research has indicated that these immigrant groups have low cancer mortality, but most studies do not use individual data.

METHODS: We apply survival analysis to the Office for National Statistics Longitudinal Study of England and Wales, to compare cancer incidence between these groups. Moreover, we follow the study population for teen years after diagnosis to identify differences between these groups in mortality following onset of cancer. We apply stepwise models to control for socioeconomic characteristics that influence health and mortality.

RESULTS: We find that the risk of cancer onset is substantially lower for individuals born in Pakistan and Bangladesh. This advantage is also observed in their British born descendants. However, following incidence of cancer there is no significant difference in mortality between these groups, and for descendants the mortality risk after onset may be elevated.

CONCLUSIONS: We conclude that lower incidence of cancer and not better survival once diagnosed is the driver of the low cancer mortality observed in Pakistanis and Bangladeshis in England and Wales. Further research is needed to show how protective

behaviours prevent the onset of cancer but fail to improve survival. Our contribution of using detailed individual administrative data to investigate both incidence and onset of cancer across immigrant generations simultaneously is novel and sheds more light on the topic of immigrant health.

5.1. Introduction

Cancer is one of the most common causes of mortality in industrialised countries, accounting for around 30% of deaths in 2019 (Institute for Health Metrics and Evaluation, 2022). With global mobility increasing, it is important to understand differences in cancer incidence and mortality between immigrants and host populations (Parkin and Khlat, 1996). Cancer disparities between subpopulations can relate both to incidence (i.e., chance of developing cancer in the first place) and subsequent survival after diagnosis.

This study investigates both cancer onset and mortality among Pakistani and Bangladeshi immigrants and their descendants in England and Wales. We aim to answer three questions: First, how does cancer onset differ between White British, Pakistani and Bangladeshi immigrants, and their descendants? Second, following onset is there a difference in survival between White British, Pakistani and Bangladeshi immigrants, and their descendants? Third, can any differences in onset or survival be explained by socio-economic factors?

Our study extends previous studies on immigrant cancer in England and Wales in the following ways. First, we investigate differences both in the incidence and survival of cancer between immigrants, descendants, and natives. Immigrant and minority cancer research in England and Wales has previously taken an approach that looks either at cancer incidence (Harding and Rosato, 1999; Winter *et al.*, 1999; Delon *et al.*, 2022) or cancer mortality (Wild *et al.*, 2006; Harding, Rosato and Teyhan, 2009; Mangtani *et al.*, 2010; Maringe *et al.*, 2015; Wallace and Kulu, 2015). Where research has looked at both the focus was on specific cancers and limited to certain geographic areas of England (Jack, Davies and Møller, 2009, 2010; Jack *et al.*, 2013). Second, we distinguish between immigrants and their descendants, which only a few studies in this destination context have done (Mangtani *et al.*, 2010). This is important as the experiences and acculturation of the foreign-born differ between generations which may lead to different health behaviours. Moreover, studies often combine Pakistanis and Bangladeshis together, often with Indians too, which has wider implications due to the heterogeneity of migrants from this region (Bhopal *et al.*, 1999; Peach, 2006). Finally, we use individual level longitudinal data to address our research questions, the Office for

National Statistics Longitudinal Study (ONS-LS) of England and Wales. The ONS-LS contains linked census and life events data for 1% of the population of England and Wales. Using this data, we present a complete picture of all-cancer incidence and survival differences comparing Pakistani and Bangladeshi immigrants, their descendants and ancestral White British across England and Wales. Using the ONS-LS also allows us to consider whether individual sociodemographic factors help explain cancer disparities between immigrant groups and generations.

5.2. Background

5.2.1. Cancer incidence and mortality in migrants

Studies of migrant mortality indicate that selection helps to explain lower mortality in immigrant groups (Abraido-Lanza *et al.*, 1999; Chiswick, Lee and Miller, 2008; Constant, 2017; Constant and Milewski, 2021) and this advantage is found to reduce the longer a migrant lives in the new country (Abraido-Lanza *et al.*, 1999; Constant, 2017). Migrants who move from less developed to developed countries move between settings that are in different stages of the epidemiological transition (Razum and Twardella, 2002). This means they experience a 'rapid health transition' (Spallek, Zeeb and Razum, 2011), upon migration chronic morbidities linked to a 'western' lifestyle are less common, whereas infection-related diseases are more common. Moving to a destination with better healthcare immediately reduces the risk of mortality from infectious diseases decreases, however with the process of acculturation new risk factors emerge (Abraido-Lanza *et al.*, 1999; Spallek, Zeeb and Razum, 2011). Some may experience a 'double burden' where early life exposures in the origin continue to be a health risk in later life alongside adopted negative health associated with developed countries (Razum and Twardella, 2002).

Immigrant cancer studies have been conducted in various contexts (see (Arnold, Razum and Coebergh, 2010) for a review). In Sweden, all-cancer incidence was found to be 5% and 8% lower for all immigrant men and women respectively (Hemminki, Li and Czene, 2002). Turkish migrants across various European contexts also show consistently lower all-cancer mortality than natives (Spallek *et al.*, 2012). Full coverage population registers in Sweden (Hemminki and Li, 2002a; Hemminki, Li and Czene,

2002; Mousavi *et al.*, 2012; Mousavi and Hemminki, 2015), Belgium (van Hemelrijck, de Valk and Vandenheede, 2017; van Hemelrijck *et al.*, 2021), the Netherlands (Stirbu *et al.*, 2006) and Norway (Thøgersen *et al.*, 2018; Hjerkind *et al.*, 2020) have added contributions that find generally lower cancer incidence and mortality for immigrants, particularly those from less developed countries. There are some exceptions to this with all cancer mortality for male Middle Eastern migrants in California higher than that of the non-Hispanic White population (Nasseri and Moulton, 2011).

These studies have found differences across cancer sites (Parkin and Khlat, 1996; Hemminki *et al.*, 2014). Cancers linked to early life infections such as liver or stomach are more common in migrants from less developed countries, whereas migrants from more developed nations and native populations are more susceptible to lifestyle driven neoplasms such as lung and breast cancer (Arnold, Razum and Coebergh, 2010). Whilst the health transition posits that time in the destination country increases the risk of lifestyle driven cancers (van Hemelrijck *et al.*, 2021) it has also been found that immigrants' risk of cancers that are caused by microbial infections and nutritional imbalances remain high no matter the duration in the destination (Hemminki *et al.*, 2014). These findings suggest that the pattern of genetic cancer risk may be set in early years in the origin country (Hemminki *et al.*, 2014).

5.2.2. Cancer incidence, and mortality among the descendants of immigrants

For the second and subsequent generations of immigrants the risk of cancer is believed to approximate levels in the host population, within one or two generations (Parkin and Khlat, 1996). The aetiologies of cancer in descendants differs from that of the parents with early life experiences being similar to that of the host population, although there is the possibility of inheritance of genetic susceptibility from parental origins (Spallek, Zeeb and Razum, 2011). However, increased likelihood in engaging with 'western lifestyle' is responsible for increases in lifestyle driven cancers in the descendants of immigrants compared to their parents' generation (van Hemelrijck, de Valk and Vandenheede, 2017).

Overall, studies on cancer incidence and mortality amongst descendants are less common due to the younger age structure of such groups, which means less statistical

power and observable cancer events in destination countries. Some European studies have shown that the second generation whose origin is a similarly industrialised European country with similar culture have fewer differences from natives for cancer incidence and mortality compared to their parents, observable in incidence for those of Nordic descent in Sweden (Hemminki and Li, 2002b) and children of French, Italian and Dutch parents in Belgium (van Hemelrijck, de Valk and Vandenheede, 2017).

Where the parental migration was from a less developed to an industrialised context, results can vary based on factors such as gender. Cancer mortality for US-born Latino men was similar to non-Latino Whites and slightly lower for US-born Latina women (Pinheiro *et al.*, 2017). Results from California for the descendants of Middle Eastern migrants show higher all-cancer mortality odds in men compared to Non-Hispanic white natives (Nasseri and Moulton, 2011). In the European context, second generation Moroccans in the Netherlands had lower all-cancer mortality risk compared to native Dutch, but no other second generation group showed the same advantage over the ancestral natives (Stirbu *et al.*, 2006).

5.2.3. Cancer in Pakistanis and Bangladeshis in England and Wales

Many previous studies on cancer in migrant populations benefit from high statistical power through use of full coverage administrative data sets on cancer and population registers. This allows for in depth focus on specific neoplasm development and subsequent mortality by country of birth and ethnic group. Data in the UK context is rather more limited.

What has been established is that all-cause mortality of immigrants in England and Wales is lower for those born in South Asia, with low cancer mortality a contributing factor to this (Wallace and Kulu, 2015). However, treating South Asian or Asian as a singular group is problematic. At times it can be necessary due to data availability but in the UK context the selection mechanisms and integration pathways of Indians differs from that of Pakistanis and Bangladeshis (Peach, 2006; Luthra and Platt, 2017). This heterogeneity materialises in varied socioeconomic outcomes and behaviours within the South Asian group (Georgiadis and Manning, 2011). These groups can have different health behaviours and differences in prior exposures that vary along social and cultural lines (Bhopal *et al.*, 1999). Thus, now that there are substantial populations of

Pakistanis and Bangladeshis in the UK at first generation level it is both theoretically optimal and practically feasible to study them separately.

Prior studies on immigrant and minority cancer in the UK context tend to either use ethnicity, thus combing immigrants with their descendants (Winter *et al.*, 1999; Jack, Davies and Møller, 2009, 2010; Delon *et al.*, 2022), or categorise using only country of birth (Harding and Rosato, 1999; Wild *et al.*, 2006; Harding, Rosato and Teyhan, 2009; Wallace and Kulu, 2015). For studies which use ethnicity, and thus combine descendants with the migrant generation, findings are consistent. The broad ethnic group of Asians (which includes Chinese) has lower all-cancer incidence consistent across most sites, the exceptions being gallbladder, Hodgkin lymphoma, liver and thyroid cancers, compared to White majority group (Delon *et al.*, 2022). The South Asian ethnic group also has better survival after cancer onset, although this has narrowed in more recent years (Maringe *et al.*, 2015). Further evidence from site-specific studies indicate that ethnic Pakistanis and Bangladeshis have lower incidence of breast and prostate cancer compared to equivalent white population, but similar chance of survival after diagnosis (Jack, Davies and Møller, 2009, 2010). For liver cancers ethnic Pakistanis and Bangladeshis have higher incidence than the White British majority (Jack *et al.*, 2013). Lastly, when compared to rates in the origin country English south Asians showed increase incidence in lifestyle driven cancers (Winter *et al.*, 1999), showing that acculturation to a western lifestyle could be a factor corroborating findings from other European contexts (Arnold, Razum and Coebergh, 2010).

For studies which use country of birth, mortality from lung, colorectal, breast and prostate cancer are all lower for the Pakistani and Bangladeshi born population compared to natives, except lung cancer in Bangladeshi men (Wild *et al.*, 2006). Another study found that all-cancer mortality was lower in Pakistani and Bangladeshi born immigrants, site-specific differences showed lower or non-different for all sites except liver cancer for both men and women and gallbladder and oral cancer in women (Mangtani *et al.*, 2010), which had higher mortality risks. All cancer mortality was lower for Pakistani born men and women but has shown converged with native-born levels over time (Harding, Rosato and Teyhan, 2009).

Cancer studies that explicitly study the descendants of Pakistani and Bangladeshi immigrants in the UK context remain scant due to the young age structure and subsequent low numbers of diagnoses. Childhood cancer incidence for children of South Asian and Pakistani descent who can be assumed to be descendants of migrants, is elevated (Cummins *et al.*, 2001; Sayeed, Barnes and Ali, 2017). In adulthood the infection related cancers, such as stomach and liver, that are higher amongst Pakistani and Bangladeshi immigrants do not affect UK born descendants to the same degree (Mangtani *et al.*, 2010) showing similarities to results found in Sweden which posit that the acculturation of second generation migrants changes the types of cancer that they are at risk of (Hemminki and Li, 2002b).

5.2.4. Cancer risk factors of Pakistanis and Bangladeshis in England and Wales

When considering the likelihood of getting, and dying from cancer, research indicates several factors to consider which could differ between the majority population and migrant and ethnic minority groups, including;

Biological differences: Pakistan and Bangladesh are countries where cancer incidence is lower (Parkin, 2004). Theories of immigrant health suggest that due to the health transition risks of infectious diseases, including infection related cancers, decrease following immigration, with acculturation increasing the risk of lifestyle driven diseases (Vanthomme and Vandenheede, 2019b). The positive selection of immigrants based on health characteristics means a healthier immigrant population on average (Chiswick, Lee and Miller, 2008), which is passed on to descendants (Spallek, Zeeb and Razum, 2011). This transmission means that the epigenetic make-up of the migrating population which has evolved due to historical events in the origin also persist (Bygren *et al.*, 2014). Epigenetic differences can have negative heath connotations too, South Asians have more insulin resistance and higher adiposity than Europeans (McKeigue, Miller and Marmot, 1989; Sniderman *et al.*, 2007). Adiposity and obesity can be considered cancer risk factors (Renehan *et al.*, 2008). Moreover, South Asians in the UK experience higher risks of cardiovascular disease and diabetes, linked to these metabolic differences (Gholap *et al.*, 2011).

Socioeconomic factors: Deprivation is associated with poorer health and negative health behaviours across the whole population (Marmot, 2020). Socioeconomic health inequities are found in cancer with clear gradients of better survival amongst higher socioeconomic groups (Woods, Rachet and Coleman, 2006; Sloggett, Young and Grundy, 2007; Hussain *et al.*, 2008). Lower socioeconomic status is more prevalent amongst Pakistani and Bangladeshis in the UK with both labour market discrimination (Larsen and Di Stasio, 2021) and occupational pay gaps (Brynin and Güveli, 2012). Controlling for these persistent disadvantages in studies of mortality explains many of the differences found that suggest a mortality disadvantage for descendants of immigrants (Wallace, 2016). An additional area of disadvantage faced by Pakistani and Bangladeshi communities is residential segregation (Shankley and Finney, 2020).

Environmental factors: Exposure to air pollution is a risk factor for neoplasm development. The residential segregation and clustering of Pakistanis and Bangladeshis is generally in urban areas (Clark and Drinkwater, 2002). This exposes both the immigrant generation and descendants to higher, potentially dangerous, levels of air pollution associated with poorer health and increased neoplasm development (Abed Al Ahad *et al.*, 2020, 2022).

Negative health behaviours: The development of negative health behaviours can be a cause of acculturation of a migrant population towards natives over time (Abraido-Lanza *et al.*, 1999; Spallek, Zeeb and Razum, 2011). Negative habits such as tobacco and alcohol consumption increase the risk of various cancers (Jemal *et al.*, 2010; Rumgay *et al.*, 2021). Amongst Pakistani and Bangladeshi women smoking rates are very low, Pakistani men smoke less than White British men and Bangladeshi men more, although for Bangladeshis deprivation can explain this gap (Karlsen, Millward and Sandford, 2012). Alcohol consumption is substantially lower than that of the native population (Wang and Li, 2019) and whilst mortality from alcohol misuse in these immigrant groups has increased over time it remains lower than White British group (Harrison, Sutton and Gardiner, 1997). Adoption of more negative health traits amongst descendants is observable however, still less than the native population (Wang and Li, 2019).

As mentioned a genetic disposition to obesity exists for Pakistani and Bangladeshis (Sniderman *et al.*, 2007), making diet an important health behaviour to consider. The diet of the immigrant generation remains rooted in traditional dishes (Jamal, 1998). These are often high in fat, salt, and oil, intake of which increases the risk of the cardiovascular health issues found (Gholap *et al.*, 2011). The acculturation of descendants' diet has conflicting views some suggest little change between generations (Wang and Li, 2019) and others suggest an increase in the negative aspects of native British diets leading to worse health for Pakistani and Bangladeshi descendants (Jamal, 1998). The prevention of obesity through physical activity is also less successful, South Asian participation in physical activity is substantially lower than that of the majority, with many barriers to participation (Fischbacher, Hunt and Alexander, 2004).

Healthcare usage and health beliefs must also be considered. Survival from cancer can be influenced by the engagement of immigrants with healthcare, including early intervention and screening programs to make early diagnosis more likely. For South Asians in the UK, relative to the rest of the population, attendance of bowel screening is around 50% and breast screening around 80% (Szczepura, Price and Gumber, 2008). These rates are even lower amongst Muslim South Asians specifically, a group more likely to include Pakistani and Bangladeshis. Explanations proposed for this include, lower knowledge of the existence of services which persists even when considering socioeconomic differences (Robb *et al.*, 2008, 2010). This also combines with sociocultural beliefs which can firstly, affect the level of fatalism associated with cancer and therefore lower understanding of the benefits of screening attendance (Vrinten, Wardle and Marlow, 2016) and secondly, lead to reliance on faith and spiritual practices for treatment rather than modern medicine (Patel, Phillips-Caesar and Boutin-Foster, 2012). Linguistic barriers are also a concern for many Asian women for presenting with symptoms or attendance at breast and cervical screenings (Szczepura, 2005) and affect South Asian participation in colorectal screening (Palmer *et al.*, 2015). The inequalities in attendance at screening and presentation continue to be an explanation for the slower increase in breast and prostate survival compared to other groups (Maringe *et al.*, 2015). Descendants do have the advantage of lower barriers to healthcare access, owing to better language knowledge and familiarity with the healthcare system, thus making

them more likely to engage with cancer screening and intervention programs compared to their parents.

5.3. Hypotheses

Based on the previous research on this topic we hypothesise that, Pakistani, and Bangladeshi immigrants will have lower all-cancer incidence relative to ancestral white British group. Thus, supporting the health transition theory (Razum and Twardella, 2002) and replicating what has been found in other immigrant cancer studies from Europe. For subsequent mortality we speculate similarly that the protective nature of their epigenetics continues to increase survival. Amongst descendants' we predict incidence to lie between that of first-generation immigrants and the native group, owing to waning maintenance of positive health behaviours. The mortality of descendants after diagnosis, is predicted to be comparable to that of the native population, given previous evidence that has suggested the mortality advantage is not found and sometimes reversed amongst descendants. We hypothesise that adjusting for socioeconomic factors will mean further increases in the advantage in cancer incidence and subsequent mortality for Pakistani and Bangladeshi groups, at both generation levels, compared to the natives. Meaning that the rates of onset and mortality become even lower than what is observed in unadjusted models.

5.4. Data and methods

We use the Office for National Statistics-Longitudinal Study (ONS-LS) (Office for National Statistics, 2019b) on a study period that runs from the census of March 1971 until the end of 2016. The ONS-LS is a longitudinal 1% sample of the population of England and Wales. It links census and life event dates such as emigration, re-entry, death, and cancer diagnosis collected from National Health Service registrations and de-registrations. An individual becomes part of the ONS-LS if they are born on one of four unspecified birth dates.

5.4.1. Sample construction

Eligibility for inclusion is based on all members of the ONS-LS, born in 1920 or later who participate in at least one census as an adult (aged over 20). Inclusion in the analytical sample is based on a combination of country of birth, parental country of

birth and ethnicity. Owing to changes in census methodology over time; parental country of birth is asked only at the 1971 census and ethnic group is available for 1991 onwards and is derived in 1971 from parental country of birth. Census responses of country of birth and more commonly ethnic group are not fixed over time (Simpson, Warren and Jivraj, 2015), whilst changes of response are most often found amongst mixed ethnic groups we use a threshold where more than half of available responses match the criteria for the individual to be included. In cases where it is exactly half, we adopt the first reported country of birth. For ethnicity we are strict with the need for more than half but do create several other samples with different inclusion criteria, see the appendix Table B1 for descriptions of different samples considered.

The majority group, ancestral White British, are defined through having the United Kingdom as country of birth in at least half of the censuses they appear at. In addition, if present at the 1971 census, all available parental birth countries must be United Kingdom. The United Kingdom in this study includes Channel Islands, Isle of Man, Scotland, and Northern Ireland in addition to England and Wales. Lastly, White or White British (earlier censuses used broader ethnic category of White, compared to later censuses where White British appears specifically) must be the ethnic group in at least half of an individual's enumerated censuses of 1971, 1991, 2001 and 2011.

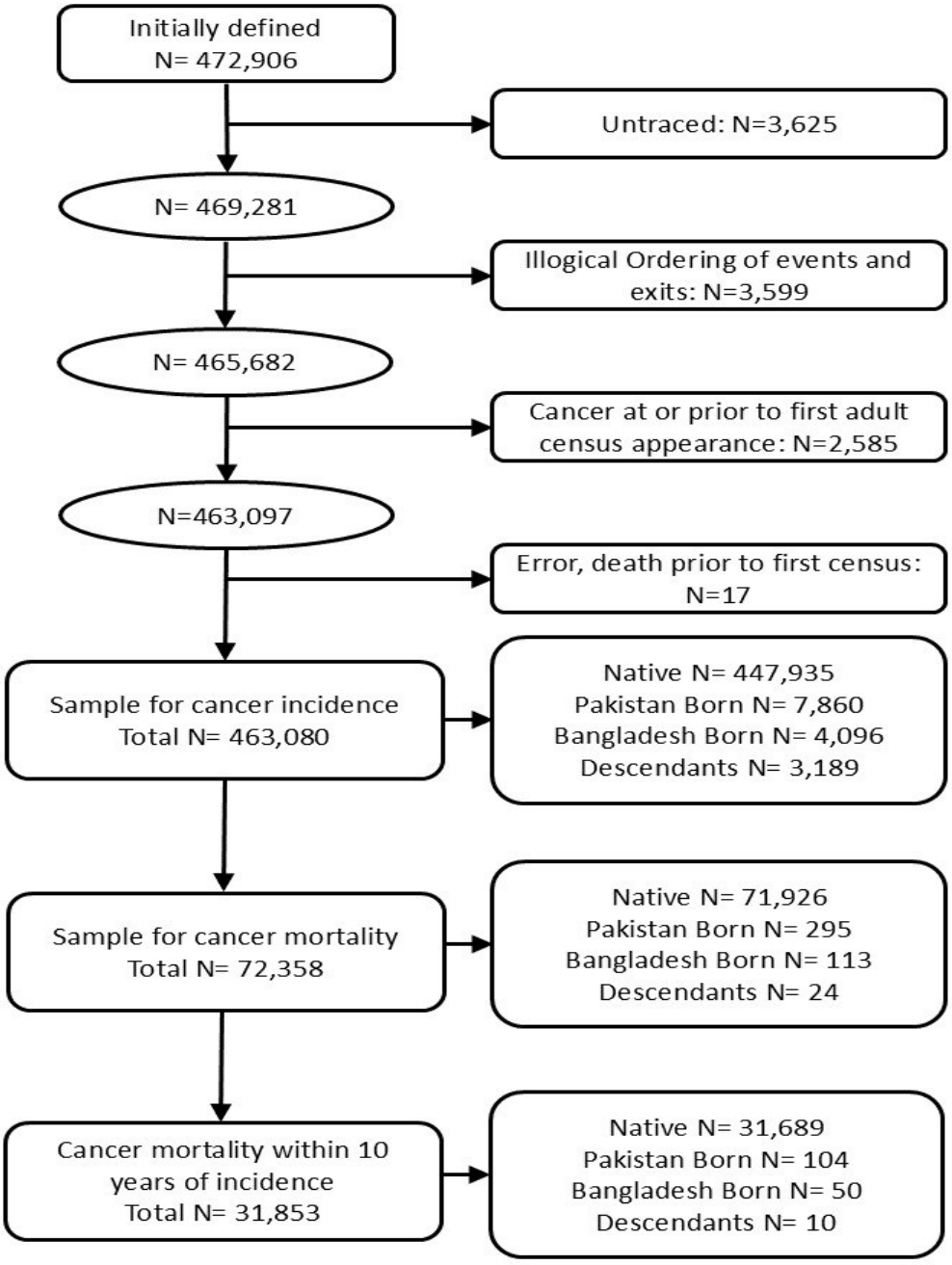
Immigrants are determined as such if their country of birth is Pakistan or Bangladesh in half or more of their census appearances. The 1971 census combined Pakistan and Bangladesh as a country of origin and ethnic group. Those who appear at multiple censuses are classified using their responses in 1981 onwards. Those who only appear in 1971 are reported as "Pakistani/Bangladeshi" thus are not included in the main sample, for sensitivity we include these people in two further samples, see appendix Table B1. We also require the self-reported ethnicity to be Pakistani or Bangladeshi, as appropriate, in over half their census appearances. This prevents White individuals born in Pakistan or Bangladesh from biasing the sample, many of these are children of expatriates born under colonialism in the early 20th who have different exposures to risk factors and epigenetics and therefore different mortality and morbidity profiles (Marmot, Adelstein and Bulusu, 1984).

The descendants group combines those of Pakistani and Bangladeshi background. The rationale behind combining is to ensure sufficient sample size as with the younger age structure of this group fewer cancer events are observed in the study period. We acknowledge that this is a limitation and recommend richer data sources be made available to identify if there are divergences in cancer outcomes between descendants of Pakistani and Bangladeshi immigrants. To be categorised in this group individuals consistently select United Kingdom as place of birth and their ethnic group as Pakistani or Bangladeshi. We call this group descendants but most are likely to be second generation due to the historical migration patterns of Pakistani and Bangladeshis (Peach, 2006), and our study's requirement of being over age 20.

5.4.2. Exclusions

Initially, 472,906 eligible members met the above requirements. Further exclusions were made on four criteria. First, being untraced (N=3,625), meaning no linkage with the national health service record meaning any cancer event cannot be linked to their census records. Second, those with an illogical ordering of entries and exits (N=3,599). Third, those who had cancer diagnosis prior to their first adult census were excluded (N=2,585). Last, a small number of cases were removed due to erroneous death dates which precede a first census appearance (N=17). Figure 5.1 details the exclusions to reach a final sample size of 463,080 and further shows the number of events that lead to being in the second analysis studying the mortality risk.

Figure 5.1 - Exclusion criteria and numbers excluded



Notes: Initially defined are individuals born 1920-1991, who are present at a minimum of one census from 1971-2011 and match the migrant origins under study
Source: ONS-LS

5.4.3. Outcome measure

Our event of interest is the incidence of first cancer. This is collected in the ONS-LS via linkage of sample members to the information provided to the English cancer registries

and the Welsh Cancer Intelligence and Surveillance Unit. These registries collect all cancer diagnoses that occur in England and Wales and are traced and matched to the ONS-LS birth dates (Henson *et al.*, 2020). Whilst the registry does record incidence of squamous and basal cell carcinomas, we do not include these as they are rarely a primary cause of death.

5.4.4. Covariates

Our main variable of interest is the migrant background, we include additional time-varying covariates. These covariates are based on answers given at the decennial census and are assumed to be fixed until the next census. Exposure time and events for each covariate can be found in Table 5.1. In Model 1 we control only for the ten-year period that the census covers and sex (sex stratified models were checked for robustness). Further models introduce time-varying covariates that attempt to measure levels of socioeconomic success and therefore inequalities which have been observed as associated with cancer incidence and survival (Woods, Rachet and Coleman, 2006; Hussain *et al.*, 2008). Migrant mortality studies that have used the ONS-LS have commonly used these covariates (Wallace and Kulu, 2015).

Model 2 includes a binary measure of education (having degree level education or above versus not; this dichotomy was selected to create comparable categories across censuses which have different education reporting due to changes in education policy. Social class is considered as an indicator of socioeconomic status which is associated with health inequalities including higher cancer incidence and worse survival (Sloggett, Young and Grundy, 2007; Rachet *et al.*, 2010; Quaglia *et al.*, 2013). Social class is measured as follows: technical and managerial, skilled, armed forces and unskilled. Model 2 also includes a measure of the spatiality with location at the time of census recorded as London, Rest of England, and Wales. We include this control to account for the devolved healthcare policies of England and Wales.

Model 3, the full model, additionally includes, marital status: never married, married, divorced, and widowed. Mortality advantages due to positive selection into marriage are observable in previous research using the ONS-LS, however cause of death specific research is less clear for Cancer (Franke and Kulu, 2018). We also include a variable measuring tenure; homeowner (with or without mortgage), rented and other. Other is

typically a ‘group home’ or institutionalisation. Tenure along with social class has been seen as a reliable indicator of cancer survival and incidence in the ONS-LS (Sloggett, Young and Grundy, 2007), and is highly related to socioeconomic success.

We retain missing categories where necessary across covariates. Missing arises when sample members miss the most recent census through non-completion or being non-resident at the time. We impute where logical based on answers given at other censuses. Namely, degree level education is projected forwards and ‘single never married’ is projected backwards to previous census periods.

5.4.5. Statistical methods

Individuals are longitudinally followed through censuses every ten years, these time points being where socioeconomic covariates are collected. We use survival analysis to measure the exposure time before a cancer incidence, whilst resident in England and Wales. Our baseline time is measured as months since turning age 20; however, entry to the risk set occurs only at the date of their first census appearance when aged over 20 for both the UK born and the immigrant groups. Information on immigration before a first census appearance is obtainable, linked through the date of registration with the NHS. However, using this date would create bias since those who do register are possibly negatively health selected as they may be seeking medical treatment. Moreover, since socioeconomic variables are only collected at census date, including immigrants at their arrival date would result in more missing amongst covariates.

Individuals can exit the sample at death and emigration. Individuals with no information relating to death or emigration following their final census appearance are deemed ‘lost to follow up’ (LTFU). These individuals are apportioned four years of exposure time following their final census appearance which is deemed the optimal amount of time based on the exit dates available in the sample (Wallace and Kulu, 2014). The exception to this is after 2011 where we assume survival to the end of the study period, which is the end of 2016.

To study both incidence of, and subsequent mortality from cancer we run two separate analyses using survival analysis, i.e., Cox proportional hazards models. First, we study individuals from their first census appearance until the event of first cancer registration. If they are never diagnosed with cancer then individuals are censored at death,

emigration, end of the study period of December 2016 or being deemed LTFU. We allow for entry and exit to the sample based on the emigration dates and re-entry dates that are linked to NHS health records. We use the mid-point of dates where there is missing information, for example estimating the exit date when we have two re-entry dates and no exit date between them, or two exit dates but no re-entry date. Cases where the ordering was illogical such as having re-entry dates before a recorded emigration date, were removed.

To study survival, we restrict the sample to only those who experience a diagnosis of any cancer during the study period N=72358. These individuals are followed for a maximum of 10 years from the diagnosis date, with the event of interest being death where the cause of death is cancer. To determine cause of death the International Classifications of Diseases (ICD) Code is used which is available in the ONS-LS through linkage to death registrations. The ONS-LS exists over three revisions of ICD codes, 1971 to 1981 is ICD-8, 1981–1999 is ICD-9 and from 2000 onwards has been ICD-10. We harmonise these ICD codes across the sample to create broad categories of deaths enabling us to dichotomise primary cause of death into either from cancer or another cause. Censoring still occurs at emigration, being LTFU, the end of the study period and death with a cause other than cancer. 4424 individuals are recorded as dying in the same month as their cancer diagnosis, these observations are allocated half a month of exposure time between diagnosis and death, on the assumption that there can be a maximum of one month variance between diagnosis and subsequent death, which if normally distributed would tend towards half a month. We conduct sensitivity analysis assigning 0.03 months (approx. one day) of survival and results were not impacted. Since the baseline is now time since diagnosis, instead of age, we include a control for five-year age bands across all models. Moreover, due to different prognoses of different cancers we introduce a control variable for the site where the cancer is diagnosed.

Table 5.1 - Number of events and total exposure time in 1000 person years for each covariate

	Panel A: Cancer Incidence		Panel B: Death after incidence	
Covariate	**Exposure time (1000 Person Years)**	**Events**	**Exposure time (1000 Person Years)**	**Events**
Total	11092	72358	331.4	31853
Immigrant Background				
Natives	10885.5	71926	329.7	31689
Pakistan Born	125.7	295	1.2	104
Bangladesh Born	53.9	113	0.4	50
Descendants	26.9	24	0.1	10
Sex				
Men	5481.7	33945	132.2	17021
Women	5610.3	38413	199.2	14832
Age Band				
20-25	367.6	411	0.5	10
25-30	988.3	1849	4.8	72
30-35	1272.6	2343	12.4	196
35-40	1301.9	2477	17.3	332
40-45	1307.5	3023	18.6	745
45-50	1278.5	4304	21.5	1288
50-55	1204.4	5980	26.9	2268
55-60	1014.6	7552	32.9	3262
60-65	822.6	9373	39.5	4251
65-70	625	10363	43.7	5022
70-75	429.2	9656	41.8	4911
75-80	270.2	7819	35.4	4502
80-85	142.8	4751	23.5	3082
85+	66.8	2457	12.5	1912
Census Period				
1971-1981	2057.4	3364	8.9	1468
1981-1991	2715.7	8470	30.6	4048
1991-2001	3259.8	18462	75.7	8472
2001-2011	3304.1	27411	134.5	11670
2011-2016	1712.4	14651	81.7	6195
Education				
Degree	1374.7	8500	46.8	2692
No Degree	9717.3	63858	284.6	29161
Social Class				
Professional, technical, and managerial	2783.1	16443	83.8	5686

Skilled	5623.4	34323	159.4	14315
Unskilled	528.7	3657	15.9	2748
Armed Forces	29.9	76	0.4	33
Missing	2126.9	17859	71.9	10071
Location				
London	1089.5	5534	22.3	2621
Rest of England	9011.3	58986	276	25132
Wales	649.7	4438	20.4	1941
Unknown/Missing	341.5	3400	12.6	2159
Marital Status				
Never Married	2425.9	8214	34.7	2616
Married	7175.9	46925	217.4	20127
Widowed	408.4	7792	34.8	4667
Divorced	798.1	6455	33.3	2578
Missing	283.7	2972	11.2	2553
Tenure				
Owner Occupied	7355.7	48797	238.9	19607
Renter	3196.4	18830	74	9244
Other	170.9	930	4.2	617
Missing	368.9	3801	14.4	2385

Source: Authors' calculations using ONS-LS

5.5. Results

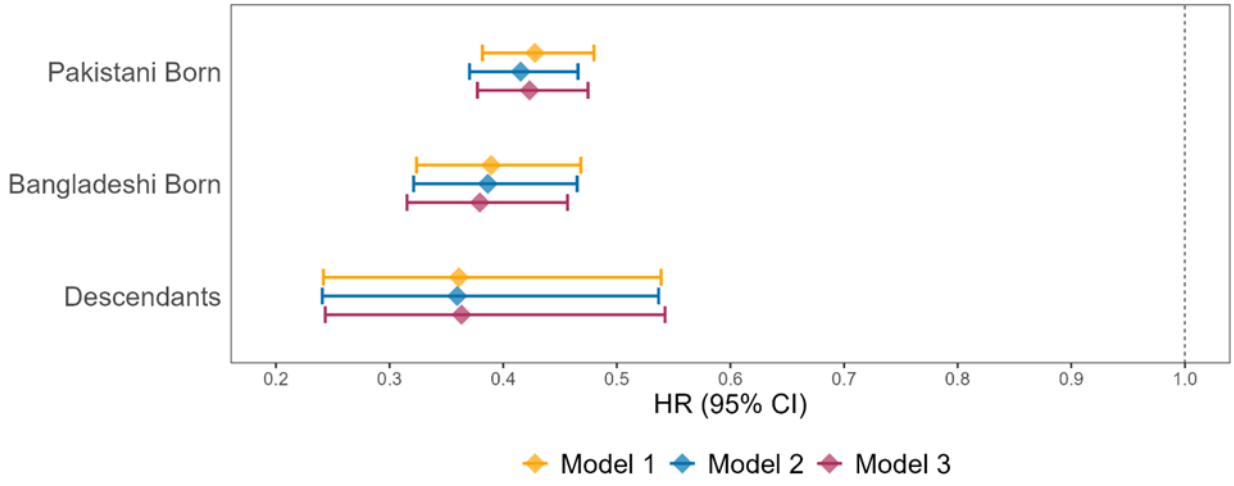
5.5.1. Incidence

Figure 5.2 shows the hazard ratios (HR) for the incidence of cancer for each migrant background and each additive model. The reference line of one indicates the Ancestral native majority group. Incidence of cancer amongst Pakistani born, Bangladeshi born, and their descendants is substantially lower than amongst White British. Relative to White British majority, the risk of cancer onset for Pakistani immigrants is approximately 42% (95% CI 0.38-0.47), for Bangladeshi born 38% (0.32-0.46) and for descendants 36% (0.24-0.54).

The introduction of covariates does little to change the magnitude of the association, with much lower rates remaining for Pakistani Born, Bangladeshi Born and the descendants across all three models, see Table 5.2. Across all models, sex is non-significant, but there is increased risk of diagnoses in later time periods, with twice the risk of cancer in 2011-2016 compared to 1971-1981 census period. This is to be expected given the average age of sample members in later time periods and better

cancer detection through screening programs. We observe a significant association of lower cancer incidence amongst those living in London compared to the rest of England and Wales. In the full model Wales and the Rest of England has approximately 12% (95% CI 1.09-1.15) higher relative risk of cancer onset than those living in London. There is variation in the effect of Social Class; compared to Managerial positions, Skilled workers have a slightly increased risk of cancer incidence. Whereas Unskilled and Armed forces have a lower risk, although the sample size which is coded as Armed forces is small. Those with degree level education or higher have a reduced risk of cancer diagnosis with a HR of 0.95 (95% CI 0.92-0.97). The final socioeconomic variable of tenure finds an that cancer incidence is more prevalent for those in rented accommodation compared to those in owner occupied homes, with HR of 1.17 (95% CI 1.15-1.19). Rates by marital status show some significant differences. Those who are divorced have elevated risk of cancer incidence whilst those widowed have lower rates. No difference is observed between those never married and married.

Figure 5.2 - Hazard Ratios of first adult cancer incidence



Notes:
1 Reference Category is Ancestral White British =1
2 95% CIs shown
Source: Authors' calculations using ONS-LS

Table 5.2 - Cox proportional hazards model: first cancer incidence in adulthood

	Model 1		Model 2		Model 3	
	HR	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Immigrant Background						
Ancestral Native	1	N/A	1	N/A	1	N/A
Pakistan Born	0.43	0.38-0.48	0.42	0.37-0.47	0.42	0.38-0.47
Bangladesh Born	0.39	0.32-0.47	0.39	0.32-0.47	0.38	0.32-0.46
Descendants	0.36	0.24-0.54	0.36	0.24-0.54	0.36	0.24-0.54
Sex						
Male	1	N/A	1	N/A	1	N/A
Female	1.01	0.99-1.02	1.00	0.98-1.01	1.01	0.99-1.02
Time Period						
1971-1981	1	N/A	1	N/A	1	N/A
1981-1991	1.28	1.23-1.33	1.27	1.22-1.32	1.29	1.23-1.34
1991-2001	1.66	1.60-1.72	1.65	1.59-1.72	1.70	1.64-1.77
2001-2011	1.93	1.86-2.00	1.94	1.87-2.02	2.00	1.93-2.08
After 2011	1.94	1.86-2.02	2.01	1.93-2.09	2.06	1.97-2.14
Location						
London			1	N/A	1	N/A
Rest of England			1.10	1.07-1.13	1.12	1.09-1.15
Wales			1.12	1.07-1.16	1.14	1.09-1.18
Missing			1.29	1.23-1.35	1.38	1.21-1.58
Social Class						
Managerial, Technical and Professional			1	N/A	1	N/A
Skilled			1.04	1.02-1.06	1.03	1.00-1.05
Unskilled			1.00	0.96-1.04	0.96	0.92-0.99
Armed Forces			0.77	0.62-0.97	0.77	0.62-0.97
Missing/Other			1.09	1.06-1.11	1.05	1.03-1.08
Education						
No Degree			1	N/A	1	N/A
Has Degree			0.94	0.91-0.96	0.95	0.92-0.97
Marital Status						
Never married					1	N/A
Married					1.02	0.99-1.04
Widowed					0.93	0.90-0.96
Divorced/Separated					1.08	1.04-1.11

Missing		0.89	0.81-0.99
Tenure			
Owner Occupied		1	N/A
Rented		1.17	1.15-1.19
Other		0.88	0.82-0.94
Missing		1.10	1.00-1.21

Source: Authors' calculations using ONS-LS

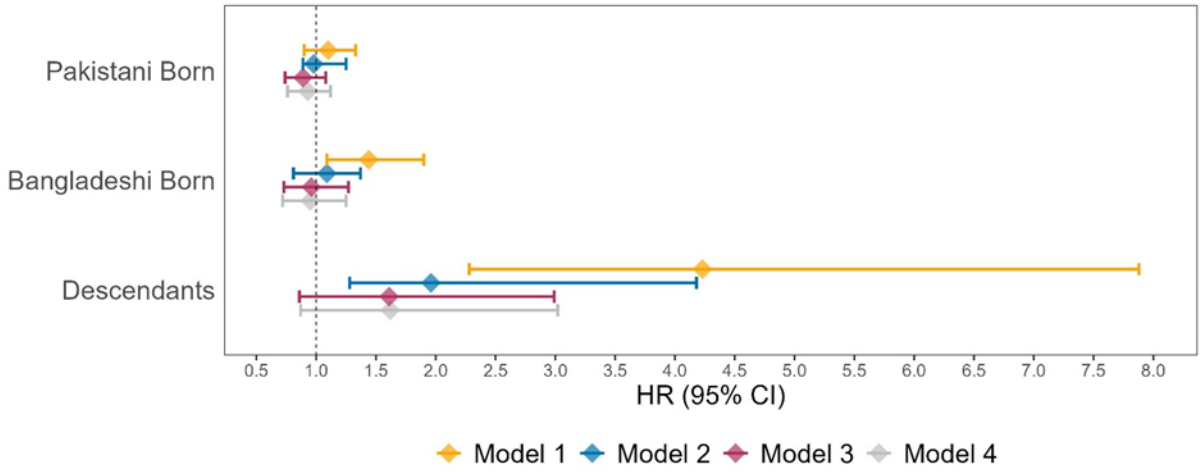
One cause of bias that could influence these findings of low cancer incidence amongst the Pakistani and Bangladeshi minority is the censoring of individuals at mortality prior to a cancer diagnosis. In theory these premature deaths are found in the unhealthiest individuals who would be the most likely to develop cancer later in the life course but are never observed experiencing the event. Meaning that the survivors into later ages are part of a select healthier group. Considering there is evidence of elevated risk of cardiovascular disease amongst Pakistanis and Bangladeshis (Gholap *et al.*, 2011) and also more deaths at younger ages amongst descendants (Wallace, 2016) it is possible that the minorities under study at older ages where cancer is more prevalent are healthier overall. To ensure that the low cancer incidence rates are not due to premature deaths in migrant populations we used the same model specifications as Model 3 above with the outcome of mortality prior to a cancer diagnosis. The hazard ratios of mortality prior to cancer are significantly lower for Pakistani born (95% CI 0.59-0.69) and Bangladeshi born (95% CI 0.55-0.71) with no significant difference for descendants (95% CI 0.74-1.51). This suggests that if there is a bias due to the censoring of unhealthy individuals prior to cancer onset it is more prevalent in the baseline native population than the minority populations under study.

5.5.2. Survival after onset

Our secondary analysis focussing on cancer mortality in the ten years following diagnosis can be seen graphically in Figure 5.3. Model 1 contains controls for sex, age and time-period, Model 2 adds in a control for site of the cancer. Model 3 adds location, social class, and education. Lastly, Model 4 considers tenure and marital status. Across all models there is no significance difference in the hazard ratio after a cancer diagnosis, for Pakistani born individuals, compared to the ancestral native reference group. For Bangladeshi born Model 1 suggests some elevated risk of death yet controlling for type

of cancer in Model 2 explains that gap. Before the socioeconomic controls are added there is some non-significant evidence that mortality after diagnosis is slightly higher for the foreign born, however this is reversed once socioeconomic controls are introduced, and never significant. For the descendants Model 1 suggests a higher risk of cancer mortality following a cancer diagnosis. Again, the strength of this association is reduced heavily through introducing the type of cancer and further still with the introduction of socioeconomic variables. The relative risk of mortality in the full model is significant at 90% with a HR of 1.62. We caution though that, for descendants in particular, statistical power is limited due to a small number of cancer onset as the previous analysis showed.

Figure 5.3 - Hazard Ratios of cancer death following incidence



Notes:
1 Reference Category is Ancestral White British =1
2 95% CIs shown
Source: Authors' calculations using ONS-LS

Results for all covariates can be seen in Table 5.3, patterns are in line with expectations, risk of death after diagnosis increases with age and over time periods the risk has deceased, a sign of the better treatment and medical developments which have increased cancer survival. We see a significant effect for sex, the risk of cancer mortality for women is over 17% lower (95% CI 0.80-0.85) compared to similar men. Differences by location are limited, London dwellers appear to have a higher relative risk of mortality compared to the rest of England. Gradients by social class are apparent, skilled, and unskilled both have higher relative risk of mortality after onset compared to those

defined in the most prestigious social class of technical, managerial and professional. Moreover, amongst those who obtain degree level education the risk of cancer death following incidence is 10% less (95% CI 0.86-0.94). Lastly, we see an association between marital status and death following diagnosis with both married and divorced individuals having lower relative risk compared to those who have never married.

Table 5.3 - Cox proportional hazards model: cancer mortality following incidence

	Model 1		Model 2		Model 3		Model 4	
	HR	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Immigrant Background								
Ancestral Native	1	N/A	1	N/A	1	N/A	1	N/A
Pakistan Born	1.10	0.90-1.33	0.98	0.89-1.25	0.89	0.74-1.08	0.93	0.76-1.12
Bangladesh Born	1.44	1.09-1.90	1.09	0.81-1.37	0.96	0.73-1.27	0.95	0.72-1.25
Descendants	4.23	2.28-7.88	1.96	1.28-4.18	1.61	0.86-2.99	1.62	0.87-3.02
Age Band								
20-25	0.14	0.07-0.26	0.24	0.13-0.44	0.23	0.12-0.42	0.20	0.11-0.38
25-30	0.15	0.11-0.18	0.24	0.19-0.30	0.24	0.19-0.30	0.21	0.17-0.27
30-35	0.21	0.18-0.25	0.32	0.27-0.37	0.32	0.27-0.37	0.30	0.26-0.35
35-40	0.30	0.26-0.33	0.39	0.35-0.44	0.39	0.35-0.44	0.38	0.34-0.43
40-45	0.55	0.51-0.60	0.67	0.61-0.73	0.66	0.61-0.72	0.66	0.60-0.71
45-50	0.75	0.70-0.80	0.80	0.75-0.86	0.80	0.75-0.86	0.80	0.75-0.86
50-55	1	N/A	1	N/A	1	N/A	1	N/A
55-60	1.23	1.17-1.30	1.13	1.07-1.19	1.12	1.06-1.19	1.12	1.06-1.18
60-65	1.41	1.34-1.49	1.27	1.20-1.33	1.25	1.18-1.31	1.25	1.18-1.31
65-70	1.62	1.53-1.70	1.44	1.37-1.52	1.40	1.33-1.47	1.40	1.33-1.47
70-75	1.78	1.69-1.88	1.61	1.53-1.70	1.54	1.46-1.63	1.54	1.46-1.62
75-80	2.13	2.02-2.25	2.01	1.91-2.12	1.88	1.78-1.99	1.87	1.77-1.97
80-85	2.56	2.42-2.71	2.46	2.32-2.61	2.19	2.06-2.32	2.16	2.03-2.30
85+	3.26	3.06-3.48	3.21	3.01-3.43	2.83	2.64-3.02	2.74	2.56-2.94
Sex								
Male	1	N/A	1	N/A	1	N/A	1	N/A
Female	0.77	0.75-0.79	0.87	0.85-0.89	0.83	0.81-0.85	0.83	0.80-0.85
Time Period								
1971-1981	1	N/A	1	N/A	1	N/A	1	N/A
1981-1991	0.70	0.65-0.74	0.77	0.72-0.82	0.76	0.72-0.81	0.77	0.72-0.82
1991-2001	0.49	0.46-0.52	0.62	0.58-0.66	0.62	0.59-0.66	0.63	0.60-0.67
2001-2011	0.33	0.31-0.35	0.45	0.43-0.48	0.47	0.44-0.49	0.48	0.45-0.51
After 2011	0.28	0.26-0.30	0.38	0.35-0.40	0.42	0.39-0.44	0.42	0.39-0.45
Cancer Type								
Colorectal			1	N/A	1	N/A	1	N/A
Bronchus/Lung			3.64	3.49-3.79	3.55	3.40-3.70	3.48	3.33-3.63
Prostate			0.48	0.45-0.51	0.48	0.46-0.51	0.49	0.46-0.52
Kidney			1.27	1.17-1.38	1.27	1.17-1.39	1.26	1.16-1.37
Bladder			0.69	0.64-0.74	0.69	0.64-0.74	0.68	0.64-0.74
Stomach			2.71	2.54-2.89	2.64	2.48-2.82	2.61	2.45-2.79
Non-Hodgkin's lymphoma			1.00	0.92-1.07	1.00	0.93-1.08	1.00	0.93-1.08
Melanoma/Skin			0.44	0.4-0.49	0.45	0.41-0.51	0.46	0.41-0.51
Pancreatic			5.15	4.81-5.50	5.14	4.81-5.49	5.14	4.81-5.49
Leukaemia			1.32	1.21-1.43	1.32	1.22-1.43	1.32	1.22-1.43

Oesophageal	2.95	2.75-3.16	2.92	2.72-3.13	2.87	2.68-3.08
Oral	0.94	0.86-1.03	0.92	0.84-1.01	0.91	0.83-1.00
Brain	4.25	3.94-4.59	4.31	4.00-4.66	4.33	4.01-4.67
Myeloma	1.52	1.37-1.67	1.52	1.37-1.67	1.51	1.37-1.67
Liver	4.29	3.88-4.75	4.24	3.83-4.70	4.25	3.84-4.70
Thyroid	0.50	0.40-0.63	0.51	0.41-0.64	0.52	0.41-0.65
Breast	0.59	0.56-0.62	0.59	0.56-0.62	0.60	0.57-0.63
Uterine	0.49	0.44-0.54	0.49	0.44-0.54	0.49	0.44-0.54
Ovary	1.68	1.56-1.81	1.68	1.56-1.81	1.69	1.57-1.82
Cervical	0.90	0.81-1.00	0.88	0.79-0.97	0.87	0.78-0.96
Other malignant neoplasm	0.43	0.41-0.45	0.43	0.42-0.45	0.43	0.42-0.45
Location						
London			1	N/A	1	N/A
Rest of England			0.92	0.88-0.96	0.94	0.90-0.98
Wales			0.93	0.88-0.99	0.96	0.90-1.02
Missing			1.15	1.09-1.23	1.15	0.96-1.38
Social Class						
Managerial, technical, and professional			1	N/A	1	N/A
Skilled			1.14	1.10-1.18	1.12	1.08-1.16
Unskilled			1.24	1.18-1.31	1.18	1.12-1.25
Armed Forces			1.04	0.74-1.46	1.02	0.72-1.44
Missing/Other			1.33	1.28-1.38	1.27	1.22-1.32
Education						
No Degree			1	N/A	1	N/A
Has Degree			0.88	0.85-0.92	0.90	0.86-0.94
Marital Status						
Never married					1	N/A
Married					0.88	0.84-0.92
Widowed					0.97	0.92-1.02
Divorced/Separated					0.90	0.85-0.96
Missing					0.77	0.68-0.87
Tenure						
Owner Occupied					1	N/A
Rented					1.15	1.16-1.22
Other					1.49	1.62-1.84
Missing					1.25	1.17-1.45

Source: Authors' calculations using ONS-LS

5.5.3. Age structure

The role of age in cancer is clear, cancer incidence and subsequent mortality increase with age as our results suggest along with others (White *et al.*, 2014). In studies related to comparing health outcomes across subpopulations age structure needs to be considered. In older ages the proportion of cancer diagnoses that are more treatable increases, in young ages more aggressive cancers make up a larger proportion which can affect overall fatality. Whilst the Cox models used do account for age and we do consider the type of cancer as an additional control in the study of prognoses. The foreign born and natives have similar time at risk within each age band, however little observation time of descendants is after age 50. To compensate for this difference, we repeated both sets of analyses censoring all observations at age 50. The results of this when we use the fully adjusted models are similar, shown in Table 5.4. Incidence remains significantly lower for all groups relative to natives and subsequent mortality remains non-different to that of natives.

Table 5.4 - Cox proportional hazards model: cancer incidence and mortality after incidence, censoring at age 50

	Cancer incidence		Cancer death after incidence	
	HR	**95% CI**	**HR**	**95% CI**
Natives (Ref)	1	N/A	1	N/A
Pakistan Born	0.44	0.36-0.55	1.13	0.73-1.74
Bangladesh Born	0.32	0.22-0.46	1.07	0.44-2.59
Descendants	0.31	0.20-0.48	2.09	0.96-4.54

Note: Only main independent variable is shown, both results are from fully adjusted models using all covariates
Source: Authors' calculations using ONS-LS

5.5.4. Sensitivity analyses

We ran several sensitivity analyses to investigate different sample specifications, descriptions, sample sizes and the hazard ratios of the independent variable on cancer incidence, see appendix Table B1 for the sample specification and Table B2 for HRs. None of these specifications altered the results. Further since the use of 'missing' as a category generates scepticism in health research (Greenland and Finkle, 1995), we repeated the analysis using only complete cases, the results hold with only small changes to the magnitude, see appendix, Table B3. Further, we consider different ways

to capture socioeconomic status by using economic position as a covariate instead of, and as well as, social class, the differences are minimal, see Table B4 in appendix.

Lastly, we considered sex stratified models, see the appendix Table B5 for incidence and B6 for subsequent cancer mortality. The socioeconomic determinants of health are likely to differ by sex (Zufferey, 2016), meaning that susceptibility to cancer may also differ. Sex stratified models still find stable results, albeit with larger confidence intervals. Thus, due to the small number of events and data restrictions we maximise sample size and statistical power by using a non-stratified sample, with sex as a covariate.

5.6. Discussion

This study supports previous findings of low cancer incidence and mortality amongst Pakistani and Bangladeshi born individuals (Wild *et al.*, 2006; Wallace and Kulu, 2015). We can add to this more certainty that low cancer mortality it is driven by the lower incidence and not by better survival after diagnosis. We find evidence that suggests amongst descendants the advantage of lower cancer incidence persists. However, in the ten years following diagnosis there is little evidence to suggest that cancer mortality differs across any groups. There is some weak evidence that mortality rates after a cancer diagnosis may be elevated for the descendants of Pakistani and Bangladeshi immigrants, however the small number of events in this group must be considered when interpreting the findings for that group. These findings support the idea of the epidemiological transition (Spallek, Zeeb and Razum, 2011) with advantages in cancer outcomes found for migrants from less developed countries in developed contexts (Arnold, Razum and Coebergh, 2010).

Our first research aim was to uncover differences in onset of cancer between the groups. We use event history analysis and Cox proportional hazards models and do find these clear differences. We build on previous research that has identified lower incidence amongst South Asian as a broad group or that has identified lower incidence for specific cancer sites (Jack, Davies and Møller, 2009, 2010; Jack *et al.*, 2013; Delon *et al.*, 2022). The analysis finds that there is a considerable advantage for immigrants from Pakistan and Bangladesh, and their descendants in England and Wales, when it comes to the onset of cancer. We speculate that there are both environmental effects related to the

overall lower burden of cancer found in the origin countries (Parkin, 2004). Alongside a maintenance of healthy behaviours (Abraido-Lanza *et al.*, 1999), which has been found in relation to, alcohol consumption and tobacco smoking (Karlsen, Millward and Sandford, 2012; Wang and Li, 2019). The low levels of incidence amongst descendants suggests a combination of inheritance of the positive selection from their immigrant parents and a continuation of these healthy behaviours (Anand *et al.*, 2008). The lack of change in cancer incidence between generations could be indicative of the low socialisation and assimilation with the majority population which has entrenched behavioural norms which have led to some better health behaviours such as low alcohol use (Bécares, Nazroo and Stafford, 2011).

Previous research finds excess rates of cardiovascular disease amongst Pakistani and Bangladeshis (Harding, Rosato and Teyhan, 2008; Gholap *et al.*, 2011; Wallace and Kulu, 2015). Therefore, survival bias could have been a reason behind these findings. Yet, the mortality hazard for migrant deaths before cancer incidence remains lower relative to the ancestral natives and is non-different for the descendants showing that this bias is not driving these results. Salmon bias and data artefacts could also be explanations of this apparent benefit, but we believe our results are robust to this based on previous analysis of this data set (Wallace and Kulu, 2014, 2018), we employed similar analytical strategy and specified risk time to those lost to follow-up in line with previous findings.

Next, we sought to find if there were differences in cancer mortality in the ten-years after cancer diagnosis. Here we find that the advantage is only present for cancer incidence, there are no differences in prognoses between observed groups. This means that health protective behaviours or genetic benefits do not appear to provide a relative advantage in survival after onset. This could be a factor of the universal health care system of England and Wales acting as an equaliser across socioeconomic boundaries of society (Asaria *et al.*, 2016). The universal health care coverage includes screening and preventative care, however previous research has identified that they are less utilised by Pakistani and Bangladeshis (Szczepura, Price and Gumber, 2008; Crawford *et al.*, 2016). Whilst this might be due to a, potentially, justified belief that cancer is less prevalent in their communities (Vrinten, Wardle and Marlow, 2016) it may lead to late detection and therefore worse survival rates.

Finally, we studied how controlling for additional socioeconomic covariates would influence the results. Overall, the covariates in our models generally follow the expected patterns, with a positive association of socioeconomic success and lower risk of cancer incidence and subsequent mortality (Sloggett, Young and Grundy, 2007; Quaglia *et al.*, 2013). Clear gradients exist across age in line with expectations, cancer diagnoses and deaths become more common in older ages (White *et al.*, 2014). Over time there are more diagnoses of cancer, attributed to better screening methods, but less risk of death due to medical interventions improving survivability for all cancers (Arnold *et al.*, 2019).

The use of socioeconomic variables does little to change the magnitude of the results for cancer incidence for any of the observed groups. Given the relatively worse socioeconomic outcomes of Pakistani and Bangladeshis (Larsen and Di Stasio, 2021) this may be deemed surprising, however further supports that it is a positive selection effect and health behaviours that drive low onset of neoplasms. When predicting the cancer mortality risk after onset the inclusion of socioeconomic controls has little impact on risk for the Pakistani and Bangladeshi born groups. For descendants, these covariates do explain much of the elevated risk after diagnosis like prior findings (Wallace, 2016). However, this analysis has a relatively small number of cancer onsets, we await a time where enough descendants have reached peak cancer and mortality ages, to truly see if accumulated disadvantage across the life course has negatively affected their longevity.

Our study is not without limitations, whilst we use a rich source of representative administrative data, there is no information around the health behaviour of the individuals in the study. Census questions do not pertain to behaviours which could be considered risk factors in cancer incidence. Therefore, we can only speculate on the persistence of health behaviours as a reason for low cancer incidence amongst the Pakistani and Bangladeshi group. Moreover, due to the decennial nature of the census our socioeconomic variables are presumed fixed for ten years until the next census. This means we lose accuracy in how much exposure time there is in each covariate, given the limited effect of socioeconomic variables on the main results this concern is minimal. Further, due to the limited number of cancer events that occur in the Pakistani and Bangladeshi population we have limited scope to delve into discussion about the types

of cancer that effects these groups, which future research with better administrative data should attempt to rectify, the low cell counts for cancer types, particularly among descendants' limits what we are able to gain clearance for publication. Research in countries with comprehensive population registers have had more success in analysing incidence and mortality of site-specific cancers (Mousavi and Hemminki, 2015) and we do find that in our sample descendants are being inflicted with more aggressive cancers in the early life course. This explains why when we censor individuals at age 50, the results hold in terms of low incidence, but there is a weak (at 90%) significance that the risk of cancer mortality for descendants after onset compared to native reference group is elevated at younger ages.

Overall, our approach and analysis add validity to previous studies which have combined Pakistani and Bangladeshi immigrant groups, with similar hazard ratios for both groups. Our findings are robust to a wide variety of sample specifications. Unfortunately, due to low event counts we lack the ability to investigate the descendants of Pakistani and Bangladeshi backgrounds separately, and with some evidence of divergence between these groups in other life domains (Georgiadis and Manning, 2011) this would be worth investigating in the future. This paper, to our knowledge, is the first to research both the incidence and survival of cancer in Pakistani and Bangladeshi immigrants and their descendants at individual level in a way that considers the potential generational differences. The low level of incidence relative to ancestral natives is persistent between generations as is the relative similarity in prognoses. Overall, we can suggest with much certainty that previous findings of low all-cancer mortality in these groups is due to lower all-cancer onset and not better survival.

6. Migrant Mortality Advantage in two different Welfare Contexts: A Comparison of England & Wales and Norway

Chapter redacted

7. Critical Discussion

Chapter redacted

8. Appendix A

Table A1 - Breakdown of highest education by immigrant status for men (unweighted %)

Highest Qualification	Native	2nd Generation	1st Generation	Total
Degree or Equivalent	33	40	28	33
A Level or Equivalent	31	37	22	31
GCSE or Equivalent	18	8	15	17
Other Qualifications	9	5	10	9
No Qualifications	9	9	23	9
Missing	0.1	0	1	0.1
Total (N)	9615	131	487	10233

Source: Authors own calculations, based on UKHLS

Table A2 - Breakdown of highest education by immigrant status for women (unweighted %)

Highest Qualification	Native	2nd Generation	1st Generation	Total
Degree or Equivalent	33	26	15	32
A Level or Equivalent	30	29	18	29
GCSE or Equivalent	20	23	15	19
Other Qualifications	8	7	13	9
No Qualifications	10	14	38	11
Missing	0.1	1	1	0.1
Total (N)	11233	125	471	11829

Source: Authors own calculations, based on UKHLS

Table A3 - Cluster validity indices for optimal cluster size

	Point Biserial Correlation	Hubert's Gamma	Hubert's C	Average Silhouette Width	Calinski-Harabasz index
Min/Max	Max	Max	Min	Max	Max
3 Cluster	0.433	0.517	0.214	0.267	4819.4
4 Cluster	0.498	0.618	0.165	0.289	3807.8
5 Cluster	0.472	0.620	0.165	0.255	3361.2
6 Cluster	0.500	0.690	0.135	0.257	2967.6
7 Cluster	0.510	0.728	0.120	0.270	2694.5
8 Cluster	0.507	0.754	0.109	0.278	2530.5
9 Cluster	0.486	0.767	0.107	0.276	2452.9

Note: Blue cells indicate the optimal result in the three to nine cluster range within that given validity index

Figure A1 - Sequence Index Plots of relationship states for full sample by cluster

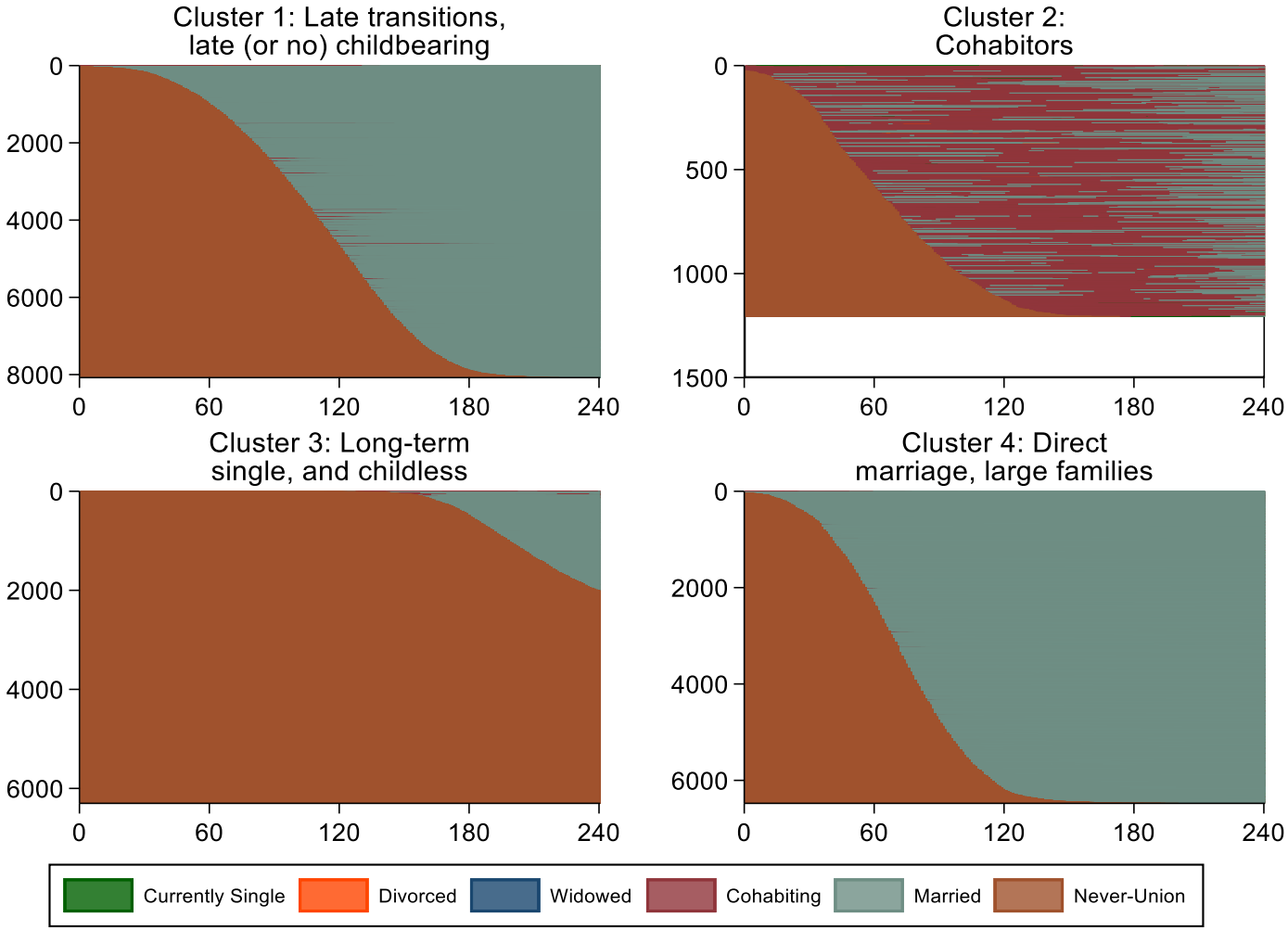
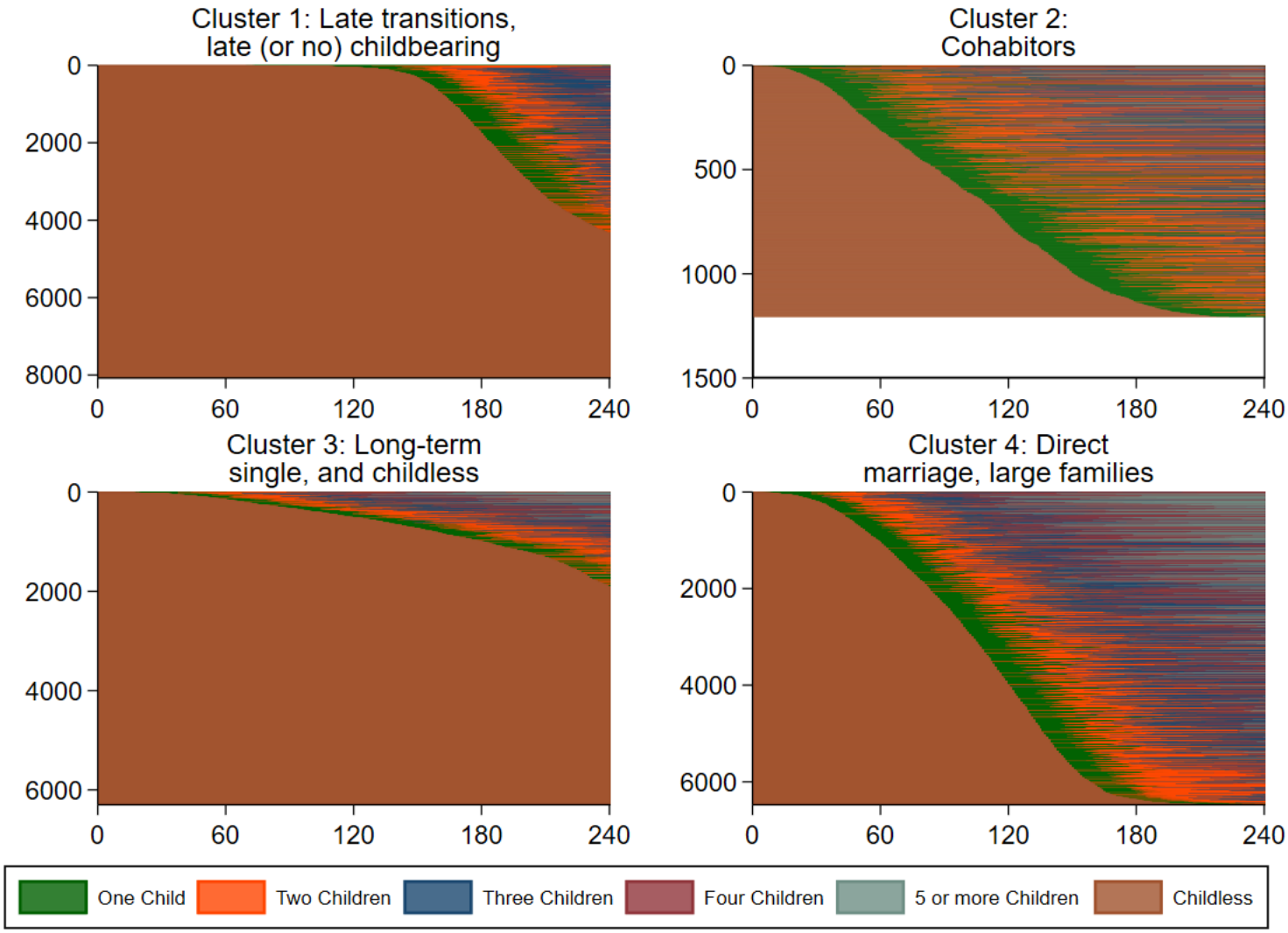


Figure A2 - Sequence Index Plots of fertility states for full sample by cluster



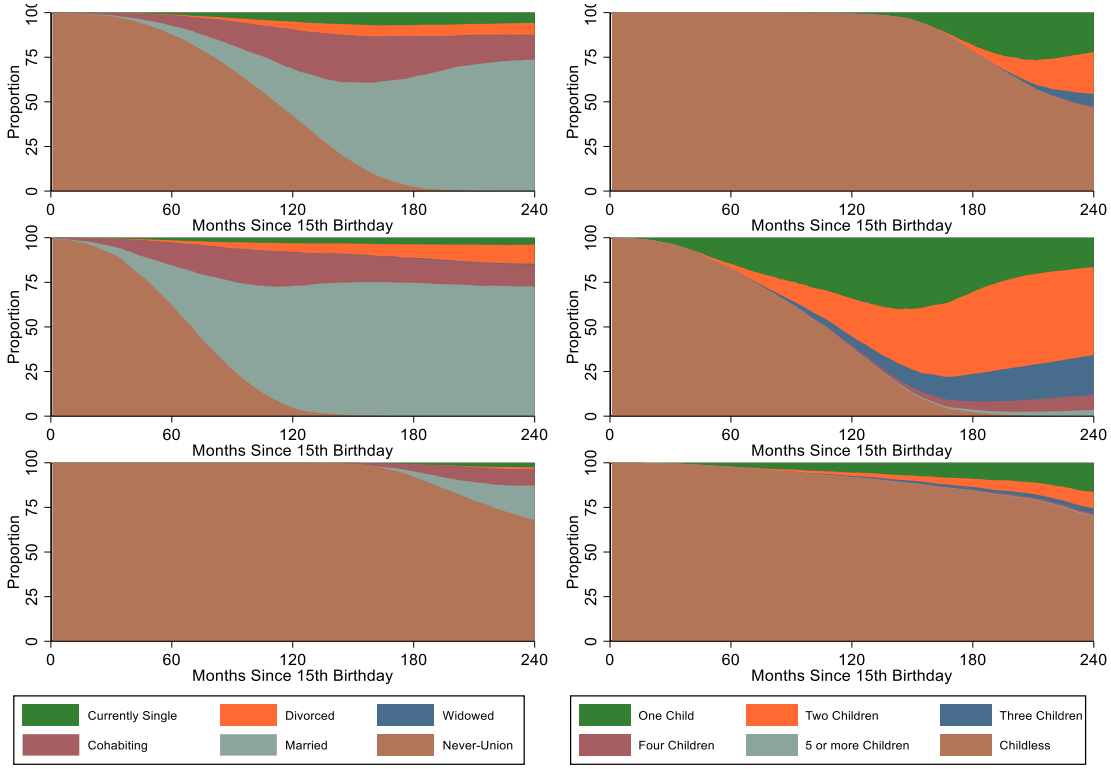
The nature of hierarchal clustering means that the three-cluster solution sees the **'Cohabitors'** and **'Direct marriage and large families'** clusters merged. We name this cluster **'Early transitions, large families**' the breakdown by immigrant generation is in Table D1.

Table A4 - Full sample clustering results by immigrant generation- three Clusters (unweighted %)

Cluster	Native	2nd Generation	1st Generation	Total
Later transitions, later (or no) childbearing	37	21	23	37
Early transitions, large families	34	45	41	35
Long term single and childless	28	34	35	29
Total (N)	20848	256	958	22062

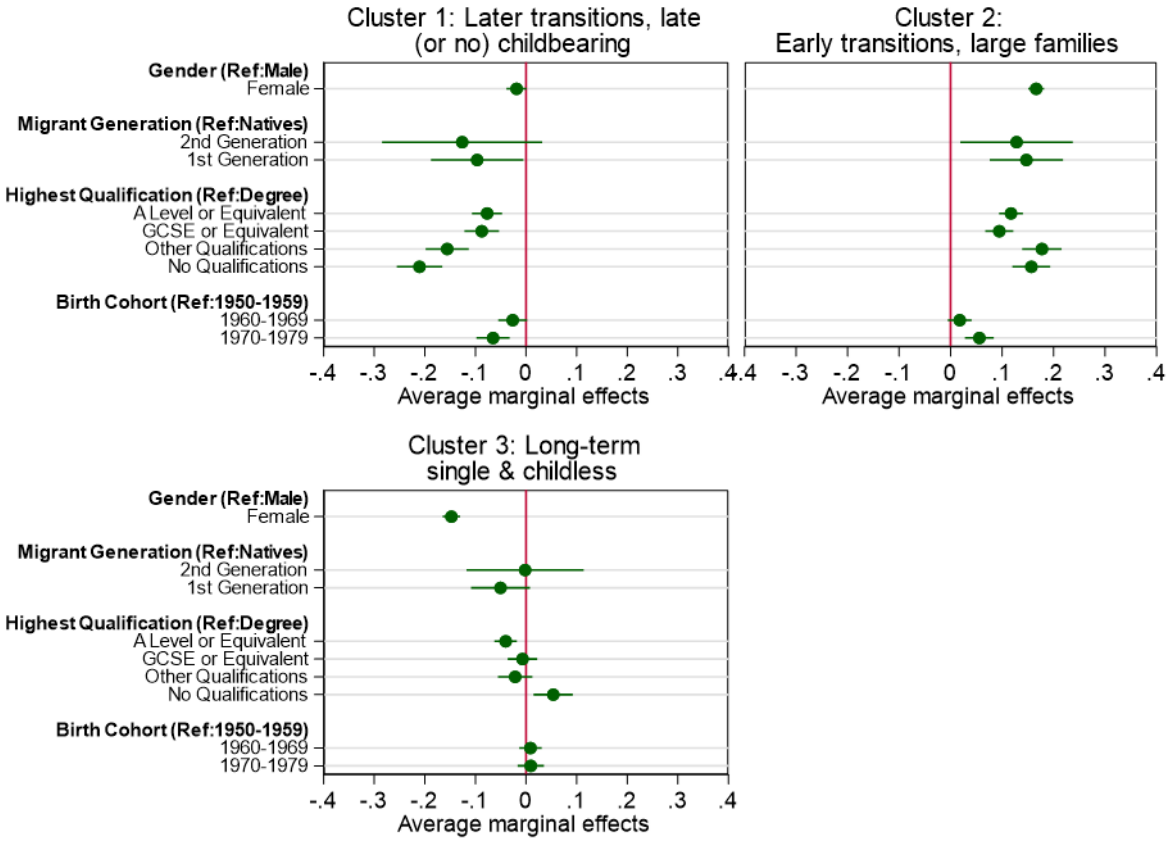
Source: Authors own calculations, based on UKHLS

Figure A3 - Chronograms of three cluster solution, full sample



Notes:
1 Left panel relationship state, right panel fertility state.
2 Top to bottom cluster one to cluster three.
Source: Authors own calculations, based on UKHLS

Figure A4 - Average marginal effects of four cluster membership - 95% CIs



Notes:
1 Red line = 0 (no marginal effect)
2 Survey weighted
Source: Authors own calculations, based on UKHLS

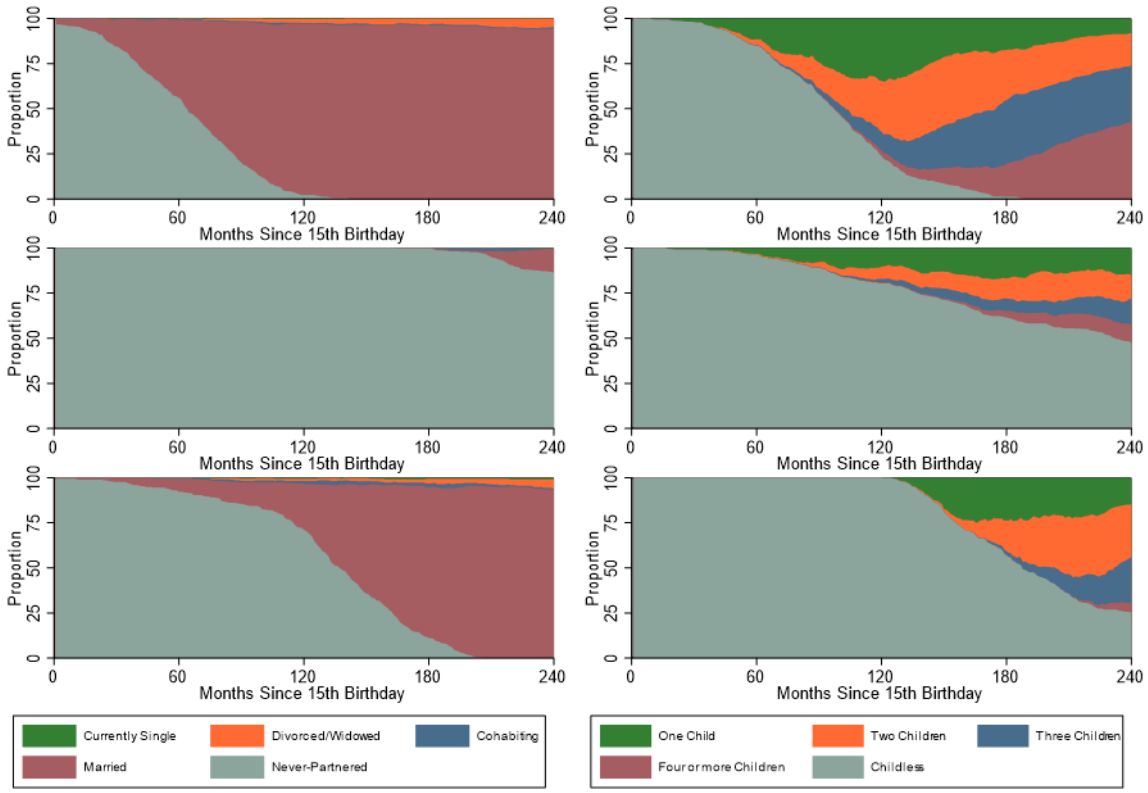
A three-cluster solution within the Pakistani only sample is in Table E1. The use of three clusters sees the **'Early marriage, large families'** and **'Early marriage, small families'** from the four-cluster solution are merged into a cluster which we name '**Early Marriage'.**

Table A5 - Cluster membership, Pakistani only sample three cluster solution (unweighted %)

Cluster	1st Generation	2nd Generation	Total
Early marriage	39	42	40
Never Partnered	32	32	32
Later marriage, smaller families	28	26	28
Total (N)	958	256	1214

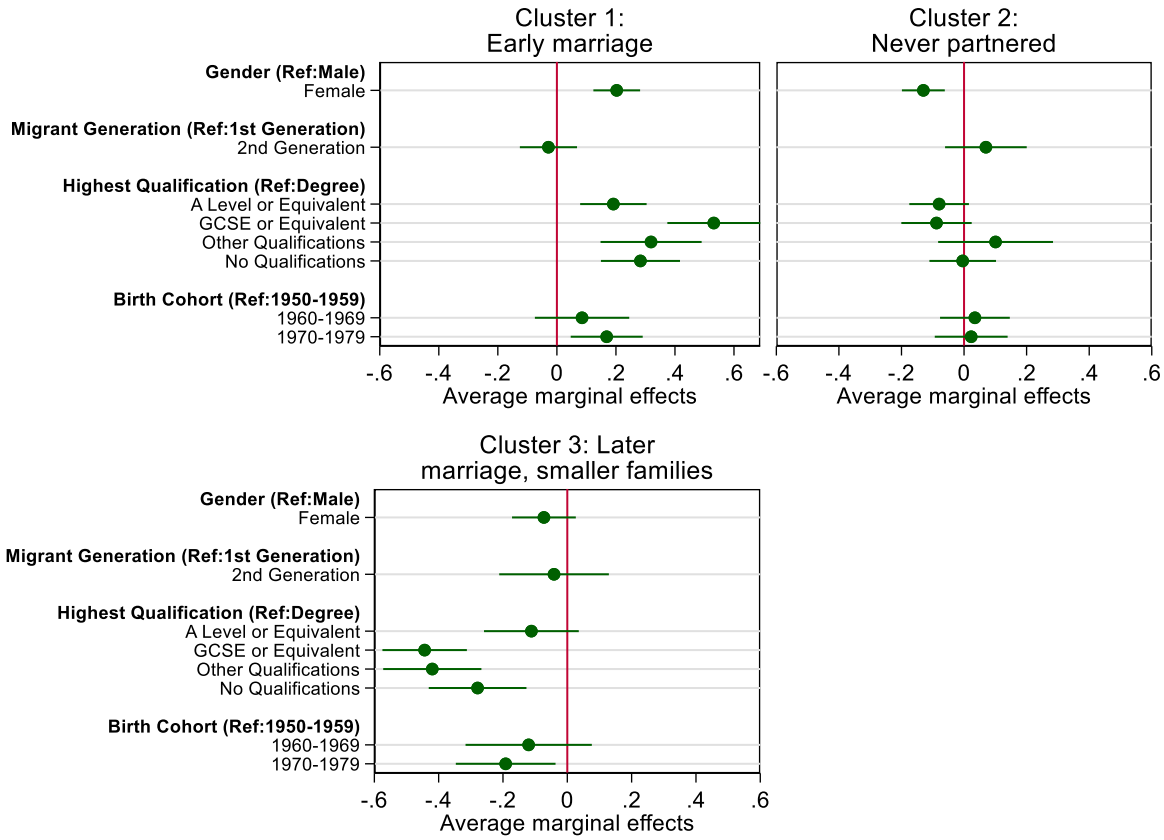
Source: Authors own calculations, based on UKHLS

Figure A5 - Chronograms of three cluster solution, Pakistani only subsample



Notes:
1 Left panel relationship state, right panel fertility state.
2 Top to bottom cluster one to cluster three.
Source: Authors own calculations, based on UKHLS

Figure A6 - Average marginal effects of probability of cluster membership- three cluster solution, Pakistani only sample - 95% CIs



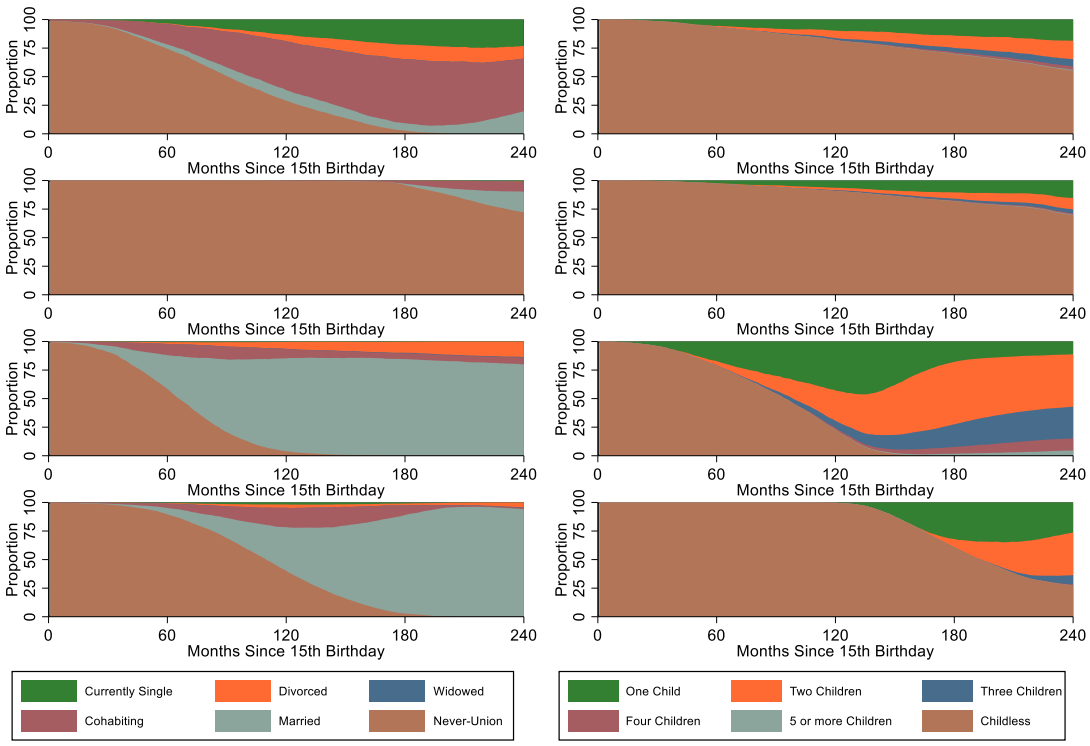
Note: Indel costs =1. Red line = 0 (no marginal effect)
Source: Authors own calculations, based on UKHLS

Table A6 - Cluster membership by immigrant generation: indel cost = 2 (unweighted %)

	Native	2nd Generation	1st Generation	Total
Cohabitors	18	4	1	17
Long-term single and childless	27	33	33	27
Earlier transitions and childbearing	23	39	48	24
Later transitions, small families	33	23	28	32
Total: N	20848	256	958	22062

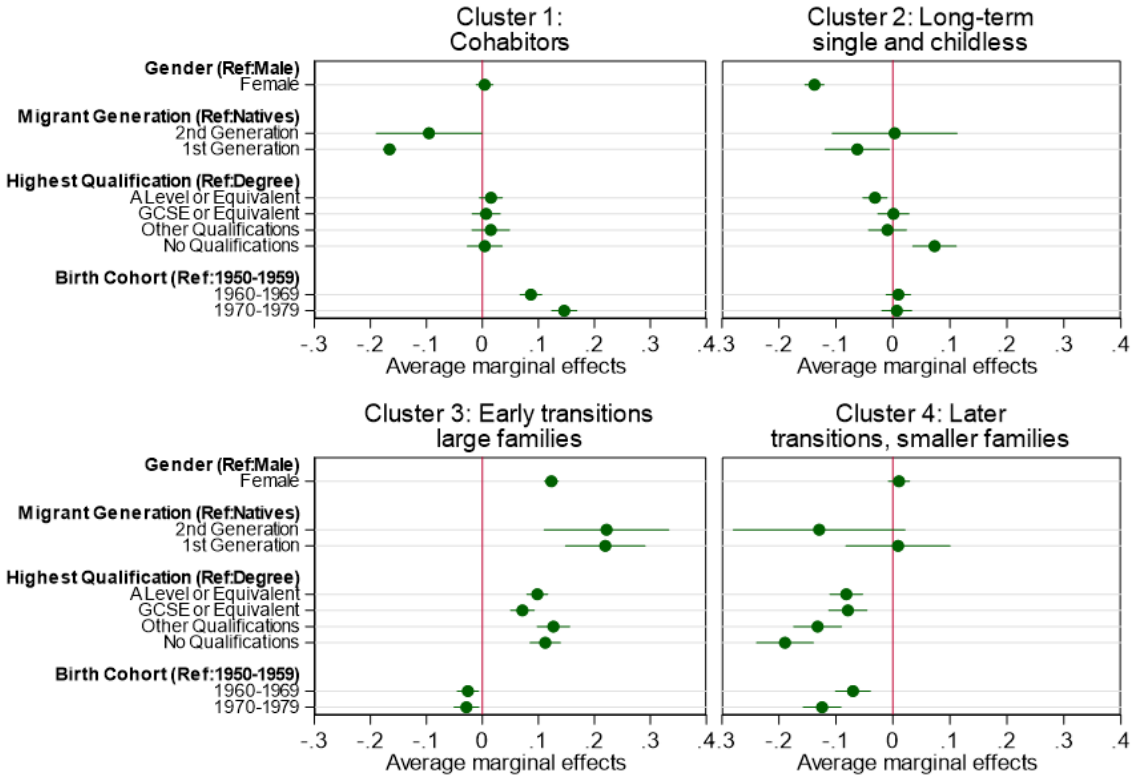
Source: Authors own calculations, based on UKHLS

Figure A7 - Chronogram of four cluster solution, whole sample: indel cost = 2



Notes:
1 Left panel relationship state, right panel fertility state.
2 Top to bottom cluster one to cluster four.
Source: Authors own calculations, based on UKHLS

Figure A8 - Average marginal effects of four cluster solution, indel cost=2 - 95% CIs.



Notes:
1 Red line = 0 (no marginal effect)
2 Survey weighted
Source: Authors own calculations, based on UKHLS

9. Appendix B

Table B1 - Descriptions of the various sample specifications used for sensitivity analyses and sample sizes

Sample	Description	Natives	Pakistan Born	Bangladesh Born	Descendants
1 (Used in main text)	Natives in 1971 must have all available parents UK Born. Immigrants only appearing in 1971 are excluded	447935	7860	4096	3189
2	Natives in 1971 need only one available parent to be UK Born. Immigrants only appearing in 1971 are excluded	460600	7860	4096	3189
3	Those who only appear in 1971 and have Pakistani/Bangladeshi as place of birth or ethnicity are assumed to be Pakistani	447935	8122	4096	3189
4	Those who only appear in 1971 and have Pakistani/Bangladeshi as place of birth or ethnicity are assumed to be Bangladeshi	447935	7860	4358	3189
5	Excludes those who ever name a country of birth that is not Pakistan, Bangladesh, or UK	446472	7637	4045	3189
6	Those who ever list Pakistan, Bangladesh as place of birth or ethnicity are included	447887	8089	4162	3616
7	Those who had equal number of responses of different country of birth (where we impute the first one reported) removed	447845	7796	4063	3189
8	Those who report a more detailed White ethnicity in 2001 and 2011 census are excluded. This is generally White Irish, White Other and Gypsy/Traveler.	447888	7860	4096	3189
9	Excludes those who ever experience an emigration event	431692	7407	3855	3031

Source: ONS-LS

Table B2 - Cox proportional hazards model: first cancer incidence in adulthood, different sample specifications

Sample Number	1	2	3	4	5	6	7	8	9
	HR	HR	HR	HR	HR	HR	HR	HR	HR
Pakistan Born	0.42	0.42	0.44	0.42	0.43	0.42	0.42	0.42	0.45
Bangladesh Born	0.38	0.38	0.38	0.43	0.38	0.38	0.38	0.38	0.39
Descendants	0.36	0.36	0.36	0.36	0.36	0.47	0.36	0.36	0.37

Notes:
1 Model used is specified exactly as Model 3 within the main text, covariate results are in line with main text.
2 Hazard ratios shown are relative to the ancestral native category and all significant at 99.9%.
Source: Authors' calculations using ONS-LS

Table B3 - Cox proportional hazards model: first cancer incidence in adulthood, complete cases only

	HR	95% CI
Immigrant Background		
Ancestral Native	1	N/A
Pakistan Born	0.51	0.44-0.59
Bangladeshi Born	0.39	0.29-0.52
Descendants	0.26	0.15-0.47
Sex		
Male	1	N/A
Female	1.08	1.06-1.10
Time Period		
1971-1981	1	N/A
1981-1991	1.30	1.24-1.36
1991-2001	1.79	1.71-1.87
2001-2011	2.04	1.95-2.14
After 2011	2.01	1.92-2.11
Location		
London	1	N/A
Rest of England	1.12	1.09-1.16
Wales	1.13	1.08-1.18
Social Class		
Managerial, Technical and Professional	1	N/A
Skilled	1.02	0.99-1.04
Unskilled	0.93	0.90-0.97
Armed Forces	0.80	0.64-1.00
Education		
No Degree	1	N/A
Has Degree	0.95	0.92-0.97
Marital Status		
Never married	1	N/A
Married	0.99	0.96-1.02
Widowed	0.92	0.89-0.96
Divorced/Separated	1.04	1.00-1.09
Tenure		
Owner Occupied	1	N/A
Rented	1.18	1.16-1.21
Other	0.90	0.83-0.98

Note: Model is specified exactly as Model 3 within the main text with cases excluded if any co-variate is missing
Source: Authors' calculations using ONS-LS

Table B4 - Cox proportional hazards model: first cancer incidence in adulthood, using economic position as an explanatory alternative to social class

	Model A		Model B	
	HR	**95% CI**	**HR**	**95% CI**
Immigrant Background				
Ancestral Native	1	N/A	1	N/A
Pakistan Born	0.41	0.36-0.46	0.42	0.37-0.46
Bangladesh Born	0.37	0.30-0.44	0.37	0.31-0.44
Descendants	0.36	0.24-0.53	0.36	0.24-0.53
Sex				
Male	1	N/A	1	N/A
Female	0.99	0.97-1.00	1.00	0.98-1.01
Time Period				
1971-1981	1	N/A	1	N/A
1981-1991	1.29	1.23-1.33	1.28	1.23-1.33
1991-2001	1.69	1.62-1.76	1.69	1.62-1.76
2001-2011	1.98	1.90-2.06	1.97	1.89-2.05
After 2011	2.05	1.97-2.13	2.04	1.95-2.12
Location				
London	1	N/A	1	N/A
Rest of England	1.11	1.08-1.14	1.11	1.08-1.14
Wales	1.12	1.07-1.16	1.12	1.07-1.16
Missing	1.37	1.19-1.56	1.37	1.19-1.56
Economic Position				
In Employment	1	N/A	1	N/A
Unemployed	1.03	0.97-1.07	1.03	0.98-1.08
Retired	1.03	1.00-1.05	1.04	1.01-1.06
Students	0.98	0.87-1.08	0.99	0.89-1.10
Permanently Sick	1.24	1.19-1.28	1.25	1.20-1.29
Other Inactive	1.15	1.12-1.18	1.18	1.14-1.21
Missing	1.08	1.03-1.13	1.12	1.06-1.18
Education				
No Degree	1	N/A	1	N/A
Has Degree	0.95	0.92-0.96	0.95	0.92-0.97
Marital Status				
Never Married	1	N/A	1	N/A
Married	1.01	0.98-1.04	1.01	0.98-1.04
Widowed	0.93	0.89-0.96	0.93	0.89-0.96
Divorced/Separated	1.07	1.03-1.11	1.07	1.03-1.11

Missing	0.90	0.81-0.99	0.90	0.80-0.99
Tenure				
Owner Occupied	1	N/A	1	N/A
Rented	1.15	1.13-1.17	1.16	1.13-1.17
Other	0.85	0.80-0.91	0.86	0.80-0.92
Missing	1.09	0.99-1.19	1.09	0.99-1.20
Social Class				
Managerial, Technical and Professional			1	N/A
Skilled			1.02	0.99-1.03
Unskilled			0.94	0.90-0.98
Armed Forces			0.77	0.61-0.96
Missing/Other			0.97	0.94-1.00

Note: Both models use all covariates, like model 3 in main text. The differences are Model A uses Economic Position instead of Social Class. Model B includes both Economic Position and Social Class

Source: Authors' calculations using ONS-LS

Table B5 - Cox proportional hazards model: first cancer incidence in adulthood, stratified by sex

	Men		Women	
	HR	**95% CI**	**HR**	**95% CI**
Immigrant Background				
Ancestral Native	1	N/A	1	N/A
Pakistani Born	0.44	0.38-0.52	0.39	0.33-0.46
Bangladeshi Born	0.44	0.35-0.56	0.29	0.22-0.39
Descendants	0.56	0.27-1.18	0.3	0.18-0.48
Time Period				
1971-1981	1	N/A	1	N/A
1981-1991	1.03	0.97-1.10	1.42	1.35-1.50
1991-2001	1.31	1.23-1.39	1.92	1.83-2.02
2001-2011	1.5	1.41-1.60	2.27	2.16-2.39
After 2011	1.49	1.40-1.59	2.41	2.29-2.55
Location				
London	1	N/A	1	N/A
Rest of England	1.1	1.05-1.14	1.14	1.1-1.19
Wales	1.14	1.07-1.20	1.14	1.08-1.21
Missing	1.56	1.29-1.90	1.15	0.94-1.41
Social Class				
Managerial, Technical and Professional	1	N/A	1	N/A
Skilled	1.04	1.01-1.07	1.02	0.99-1.05
Unskilled	1.06	1.00-1.12	0.95	0.90-1.00
Armed Forces	0.89	0.70-1.15	1.06	0.62-1.83
Missing/Other	1.11	1.07-1.16	1.05	1.01-1.09
Education				
No Degree	1	N/A	1	N/A
Has Degree	0.93	0.90-0.96	0.93	0.89-0.96
Marital Status				
Never Married	1	N/A	1	N/A
Married	1.03	0.99-1.08	0.89	0.86-0.92
Widowed	1.08	1.02-1.15	0.95	0.91-1.00
Divorced/Separated	1.08	1.02-1.14	0.97	0.93-1.02
Missing	0.84	0.74-0.96	0.95	0.80-1.13
Tenure				
Owner Occupied	1	N/A	1	N/A
Rented	1.17	1.14-1.21	1.13	1.11-1.16
Other	0.9	0.82-1.00	0.87	0.79-0.95
Missing	1.04	0.89-1.21	1.16	1.03-1.31

Source: Authors' calculations using ONS-LS

Table B6 - Cox proportional hazards model: cancer mortality following incidence, stratified by sex

	Men		Women	
	HR	**95% CI**	**HR**	**95% CI**
Immigrant Background				
Ancestral Native	1	N/A	1	N/A
Pakistan Born	0.92	0.71-1.18	0.96	0.71-1.31
Bangladesh Born	0.87	0.62-1.22	1.21	0.74-1.98
Descendants	2.08	0.78-5.59	1.28	0.57-2.85
Age Band				
20-25	0.40	0.16-0.96	0.15	0.06-0.36
25-30	0.47	0.34-0.68	0.15	0.11-0.21
30-35	0.44	0.34-0.57	0.28	0.23-0.33
35-40	0.50	0.41-0.60	0.36	0.31-0.42
40-45	0.82	0.72-0.93	0.59	0.53-0.66
45-50	0.79	0.71-0.87	0.82	0.75-0.90
50-55	1	N/A	1	N/A
55-60	1.08	1.00-1.16	1.15	1.07-1.25
60-65	1.15	1.07-1.24	1.34	1.24-1.44
65-70	1.29	1.20-1.39	1.49	1.38-1.60
70-75	1.41	1.31-1.52	1.66	1.53-1.79
75-80	1.73	1.60-1.87	1.97	1.82-2.13
80-85	1.98	1.81-2.15	2.32	2.12-2.53
85+	2.56	2.32-2.82	2.90	2.63-3.19
Time Period				
1971-1981	1	N/A	1	N/A
1981-1991	0.80	0.73-0.88	0.76	0.70-0.83
1991-2001	0.69	0.64-0.76	0.60	0.55-0.65
2001-2011	0.52	0.48-0.57	0.45	0.41-0.49
After 2011	0.46	0.42-0.50	0.39	0.36-0.43
Cancer Type				
Colorectal	1	N/A	1	N/A
Bronchus/Lung	3.55	3.35-3.75	3.46	3.24-3.70
Prostate	0.52	0.48-0.55	(Omitted)	
Kidney	1.21	1.09-1.34	1.44	1.26-1.66
Bladder	0.68	0.62-0.74	0.76	0.67-0.87
Stomach	2.79	2.58-3.03	2.35	2.10-2.63
Non-Hodgkin's lymphoma	1.06	0.96-1.16	0.91	0.81-1.02
Melanoma/Skin	0.58	0.50-0.67	0.35	0.30-0.41
Pancreatic	4.92	4.49-5.38	5.40	4.89-5.96
Leukaemia	1.32	1.19-1.47	1.29	1.14-1.47
Oesophageal	3.00	2.75-3.27	2.69	2.39-3.02

Oral	0.94	0.84-1.05	0.85	0.72-1.00
Brain	4.29	3.88-4.74	4.12	3.66-4.65
Myeloma	1.46	1.27-1.67	1.60	1.38-1.85
Liver	4.23	3.72-4.80	4.51	3.81-5.34
Thyroid	0.61	0.43-0.86	0.44	0.33-0.59
Breast	0.43	0.28-0.66	0.56	0.53-0.60
Uterine	(Omitted)		0.46	0.41-0.51
Ovary	(Omitted)		1.59	1.47-1.73
Cervical	(Omitted)		0.83	0.74-0.93
Other malignant neoplasm	0.51	0.48-0.54	0.36	0.34-0.39
Location				
London	1	N/A	1	N/A
Rest of England	0.94	0.89-0.99	0.95	0.89-1.00
Wales	0.96	0.88-1.04	0.96	0.88-1.04
Missing	1.14	0.88-1.48	1.15	0.87-1.52
Social Class				
Managerial, technical, and professional	1	N/A	1	N/A
Skilled	1.13	1.08-1.18	1.11	1.05-1.17
Unskilled	1.18	1.10-1.28	1.17	1.08-1.27
Armed Forces	1.00	0.70-1.43	1.10	0.35-3.43
Missing/Other	1.28	1.21-1.35	1.23	1.16-1.31
Education				
No Degree	1	N/A	1	N/A
Has Degree	0.90	0.85-0.95	0.89	0.83-0.96
Marital Status				
Never married	1	N/A	1	N/A
Married	0.88	0.83-0.94	0.88	0.82-0.94
Widowed	0.99	0.92-1.07	0.95	0.88-1.02
Divorced/Separated	0.94	0.87-1.02	0.87	0.80-0.95
Missing	0.77	0.66-0.89	0.78	0.63-0.96
Tenure				
Owner Occupied	1	N/A	1	N/A
Rented	1.15	1.11-1.20	1.15	1.11-1.20
Other	1.50	1.34-1.68	1.49	1.32-1.67
Missing	1.23	1.00-1.51	1.29	1.08-1.53

Source: Authors' calculations using ONS-LS

10. Appendix C

Appendix redacted

11. References

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