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CLARKE, A, QUINN, Lorna and PEAT, George <http://orcid.org/0000-0002-9008-0184>

The distribution of healthcare workforces relative to population ill health in England: Repeated cross-sectional analysis of Census data 2001–2021

A. Clarke[a], L. Quinn[a,b,*], G.M. Peat[a]

[a] Centre for Applied Health & Social Care Research (CARe), School of Health & Social Care, Sheffield Hallam University, UK

[b] Public Health, Rotherham Metropolitan Borough Council, UK

* Corresponding author

ABSTRACT

Objectives: To investigate inverse and positive care laws for the geographic distribution of different healthcare workforces in England between 2001 and 2021

Study design: Repeated, cross-sectional, ecologic study at the level of Local Authorities (2001, 2011, 2021) and Integrated Care Boards (2021)

Methods: Using national Census survey data for England from 2001, 2011, and 2021 we correlated the prevalence of ill health in the resident population with the proportion of different health professional groups employed in the resident working-age population. To explore the previously described Positive Care Law for informal care, we correlated with the prevalence of ill health with the proportion of the resident population providing 50+ hours of unpaid care per week.

Results: Across 2001, 2011, and 2021, the distributions of medical professionals and 'health associates and therapy professionals' were consistently inversely distributed relative to population ill health. Nursing professionals and informal caregiving were consistently positively correlated. Data available in 2021 on detailed professional groups revealed wide variation in the distribution of different professional groups relative to population ill health: speech and language therapists (r=-0.456), complementary health associate professionals (r=-0.478), and psychotherapists/cognitive behaviour therapists (r=-0.558) showed the strongest inverse correlation with population ill health. Pharmaceutical technicians (0.774), nursing auxiliaries/assistants (0.764), and care workers/home carers (0.746) were among the most positively correlated.

Conclusions: Inverse and positive care laws for healthcare workforce distribution in England appear largely unchanged over the past 20 years. Marked variation between different health professions suggests the need for targeted actions to improve equitable distribution.

Keywords: Inverse Care Law; health and social care workforce; unpaid care; human health resources

INTRODUCTION

Over 50 years have passed since Julian Tudor Hart's landmark publication on the Inverse Care Law.[1] Yet the original assertion "that the availability of good medical care tends to vary inversely with the need of the population served" still appears to holds across many health services and settings.[2,3] Inequitable distribution of services and workforces has been reported in helicopter emergency medical services[4], general practice consultations[5], primary care dental services for children[6], hip replacements[7], mental health screening in pregnancy[8], and end of life care[9]. Successful healthcare workforce planning - "getting the right people with the right skills and competences *in the right place* at the right time to deliver services that provide the best possible patient care, within a budget that you can afford"[10] - is fundamental to efforts to improve health and reduce health inequalities.[11–13] However, UK government plans for the NHS in England acknowledge that "too often, the poorest services are in the poorest communities, where need is also highest"[14] and recognise "entrenched inequalities in the distribution of staff".[15]

The persistence and ubiquity of the Inverse Care Law suggest it is a "banal truism". An inverse care law or disproportionate care law, applies in most, if not all countries.[16] Inequalities in the distribution of human resources for health between countries and territories is a longstanding global problem which, although possibly decreasing overall within the past 30 years, nevertheless continues to persist.[17] Furthermore, there is consistent evidence that almost all countries have subnational inequalities in the numbers of health personnel per total population.[18] For example, in a study of 58 different countries, Boniol et al.[19] found an average 11-fold difference between regions with the highest and lowest densities of nursing

personnel, but with the greatest differences seen in African countries. Within the European Union, such regional differences appear not to have improved over time.[20] Patterns of maldistribution are not the same across different professional groups: for example, physician density in many countries appears greatest in capitals and major cities, but this is often not the case for nurses and midwives.[20] Despite its ubiquity, Tudor Hart was clear that the inverse care law is a human construct, not a law of nature, and that it need not be fixed and immutable.[21] Using Census 2001 data at local authority level, Shaw and Dorling[22] showed that the Inverse Care Law may apply with differing levels of force to different healthcare professional groups. Those health professionals working in the most highly paid professions or providing private services were more likely to be living in places with relatively low levels of population health need. Evidence of a North-South divide in England suggested that commutable distances between where health professionals lived and worked could not fully account for such inequitable distribution. Even more striking was their finding of a Positive Care Law in which the distribution of informal caring was strongly positively correlated with the prevalence of poor health.

A limitation of Shaw and Dorling's work was that Census 2001 analysis was only undertaken on relatively broad categories of occupation. More granular occupational data available in the most recent Census (2021) offers the opportunity to compare the different patterns of health workforce distribution for different professions in greater detail. Shaw & Dorling's work presented a snapshot in time, but the picture may change. In England, rising overall numbers of full-time equivalent healthcare professionals directly employed in the NHS[23] hides variable and changing patterns of growth and geographical distribution for different professional groups. The overall supply of adult community nursing and support workers, for example, has dropped although the inequitable distribution across regions has remained.[24] Policy initiatives, both system-wide or specific to professions or sectors, may have varying levels of

effectiveness in re-distributing the healthcare workforce to those places and populations with the greatest need (e.g.[25]). These include the emergence of new healthcare careers, such as additional roles in primary care and nursing and medical associates, the opening of new medical schools in previously 'under-doctored' regions, and changing patterns of entry (e.g. degree apprenticeships) and exit from the healthcare workforce.

Our study therefore sought to update and extend the previous descriptive study of Shaw and Dorling. Specifically, we used national Census survey data for England from 2001, 2011, and 2021 to investigate: whether the extent of inverse distribution of healthcare professional workforces relative to population measures of 'need' has changed over the past two decades; how great are the differences in distribution between healthcare professional groups; whether there is still a strong positive care law for informal caregiving.

METHODS

Overview of study design

This is a repeated cross-sectional ecologic (correlational) study using census data for England from 2001, 2011, and 2021 and aggregated to county/unitary local authority level and, for 2021 data only, at the level of Integrated Care Boards (ICBs). For each year, we correlated the prevalence of ill health in the total resident population with the proportion of different health professional groups employed in the resident working-age adult population (16-64-years-old), and with the proportion of the resident population aged 5 years or over providing 50+ hours of informal care per week.

Data sources

National Census survey data for England were used for this analysis. The Census is undertaken by the Office for National Statistics every ten years asking questions about a person, their household and their home. It is sent to every household, individual, and communal establishment in England and Wales. Administration of the survey took place around a designated Census Day (29 April 2001, 27 March 2011, 21 March 2021). Over time, data collection evolved from an 8-page paper questionnaire in 2001 to a 32-page online and paper questionnaire in 2011 and 2021, with 2021 adopting a digital-first strategy that saw 89% of survey completions done online. Questionnaires in all three surveys have been available in English and Welsh languages, with additional support for completion from a variety of sources including voluntary and community organisations, online help facility, telephone helpline, and in 2021 with translation leaflets in >40 languages and interpreters available if required. Extensive consultation, pre-testing, and comprehensive publicity campaigns precede Census administration, e.g. Census Tests surveyed 100,000 households in purposively selected local authorities in 2007 and 2017, and were followed by Census Rehearsals in 2009 and 2019 targeting 135,000 and 331,359 households respectively. Further details of the quality management processes for the Census are publicly available.[26] Response rates are high (98% in 2001, 94% in 2011 and 97% in 2021, with response rates in every local authority over 80% with the exception of a small number of inner-city London authorities in 2001). Census questionnaires are available open access from the UK Data Service (https://ukdataservice.ac.uk/learning-hub/census/resources/census-forms/). The current analysis used anonymised, aggregated Census data for England, obtained from Nomis Explorer (**Supplementary Data Table S1**).

In England, as of 2021 to align with Census data, there were 152 upper tier local authorities made up of 59 unitary authorities, 36 metropolitan districts, 33 London boroughs (including City of London) and 24 counties. We used the 152 upper tier local authorities from the 2021 Census for all three census years. As per Shaw & Dorling, we combined the 33 London Boroughs into one 'London' value given the increased likelihood of healthcare professionals living in one Borough but commuting to work in another London Borough (**Supplementary Data Table S2**). Therefore, we completed the analysis with 120 locations in England in 2021 (118 in 2001 and 2011 due to changes in local authority boundaries and availability of Census geographical data).

Defining ill-health

Self-reported ill-health was defined as the combination of poor self-rated health and long-term limiting illness. Question phrasing and response options varied slightly across the three Censuses (**Table 1**).

Classification of health professionals

We harmonised the data on health professional groups due to minor changes in occupation classification and labelling across the three Censuses. In 2001 the categories of health professionals used Standard Occupational Classification (SOC) 2000, in 2011 used SOC2010, and 2021 used SOC 2020. For example, in 2001, 'Nursing staff' was limited to 'Nurse and midwife' whereas in 2021, this detailed the type of nurse such as 'registered community, registered specialist, registered children's nurse, registered mental health nurse'. We therefore combined the appropriate detailed professions into wider categories for the comparative analyses over time (**Supplementary Data Table S3**).

Employment was self-reported and defined by a person having worked in the last seven days regardless of full-time equivalent, and includes those working as an employee, self-employed, on maternity/paternity leave, or on paid sick leave. In all three Census questionnaires, the occupation question asked if a person was working in the last seven days. Additional questions asked about their level of qualification, and job role (free text). In 2001, Census respondents were also asked specifically if they have a professional qualification within the health fields listed above. It should be noted that in their previous analysis, Shaw and Dorling used the number of those who were qualified, in that occupation, and working, as a proportion of total population. However, for this analysis, we used the number of people working in the specified occupation, regardless of qualification listed, as a proportion of all residents of working age (defined as the population aged 16-64-years-old).

Statistical analysis

For each Census year, we calculated and plotted weighted correlation coefficients, and associated p-values using a permutation test with 1000 permutations, for the correlation between the proportion of the total population (all ages) reporting ill-health in each of the 120 upper tier local authorities (London combined), and (a) the proportion of the population aged 5 years and over providing 50+ hours unpaid care per week in the same location, (b) the proportion of the working age population (16-64 years) in each health professional category and group in the same location. We repeated the analysis at Integrated Care Board (ICB) level (n=42) in 2021. To explore potential determinants of the relationship between population need and healthcare workforce, we performed subgroup analyses, based on median split for the following population characteristics in each local authority: the proportion of the population aged 0-19-years-old, proportion of the population aged 65-years-old and above, proportion of the population self-reporting ethnicity as White British, the proportion of the population with self-reported ethnicity as 'Asian, Asian British or Asian Welsh', 'Black, Black British, Black Welsh', 'Caribbean or African', 'Mixed or Multiple ethnic

groups', or 'Other ethnic group', and area-level deprivation (English Indices of Deprivation average score, 2025[27]) (**Supplementary Data Table S4**). We also repeated the analysis at Integrated Care Board (ICB) level (n=42) in 2021 rather than upper tier local authority.

Analysis was conducted in R-Studio, R version 4.4.3, using the following packages: dplyr[28], readxl[29], wCorr[30], ggplot2[31], and gridExtra[32].

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

In 2001 in England, 7.42% of the population self-reported ill health. In 2011 this was 5.05%, and 4.77% in 2021. The proportion of the population providing 50 or more hours of unpaid care each week increased slightly from 2.16% in 2001 to 2.53% in 2011, and 2.49% in 2021. The proportion of the working aged population who were categorised as nursing staff was 1.58% in 2001, 1.49% in 2011, and 1.64% in 2021. For health associates and therapists, this was 0.58%, 0.60%, and 0.77% respectively, and for medical practitioners, 0.63%, 0.87%, and 1.10% respectively.

Provision of unpaid care was consistently strongly positively correlated with ill health. Nursing staff were also positively correlated with ill health, whereas health associates and therapy professionals, and medical practitioners were negatively correlated with ill health (or weakly positively correlated in the case of medical practitioner in 2011) (**Table 2; Figure 1**).

Repeating the analyses using the more detailed health professional groups available in 2021 Census data suggested differences in the direction of the correlations between professions in the same broad category. For example, within allied health professionals, the distribution of podiatrists (weighted correlation coefficient 0.242), medical radiographers (0.199), paramedics (0.108), and occupational therapists (0.055) was positively associated with the distribution of ill health. By contrast, physiotherapists (-0.283) and speech and language therapists (-0.456) were negatively associated with the distribution of ill health (**Table 3**). Complementary health associate professionals, psychotherapists and cognitive behaviour therapists, other psychologists (excludes clinical psychologists), and therapy professionals not elsewhere classified were the most strongly negatively correlated with the distribution of ill health in the population.

Subgroup analyses suggested that the positive correlations seen across all local authorities between the prevalence of ill health and the proportion of the population providing informal caring and the proportion of the population working in nursing were also seen in local authorities with higher than median levels of young people, old people, those from White British and ethnic minority backgrounds, and deprivation. A slightly stronger negative correlation between ill health and the proportion of medical professionals was seen in local authorities with older and more White British residents. For health associates and therapy professionals, correlations with ill health were more negative across all subgroup analyses, particularly local authorities with a higher proportion of White British residents and residents who were more deprived (**Table 2)**.

Repeating the analyses at the level of Integrated Care Boards showed a more positive correlation for most health professionals. When comparing the change between local

authority to ICB estimates, three health professionals shifted from a negative correlation to positive; midwifery nurses, pharmacists, and heath associate professionals n.e.c. Health professionals with the strongest positive correlation for local authority estimates, pharmaceutical technicians, nursing auxiliaries and assistants, care workers and home carers, registered nurse practitioners, and registered mental health nurses all had a stronger weighted correlation for ICB compared to local authority with the exception of care workers and home carers which shifted from 0.746 to 0.733. (**Table 3**)

An interactive report created in Power BI is available for access at https://app.powerbi.com/view?r=eyJrIjoiMGEzMjNlNGMtOWI1Yy00NWUyLWJlZDktYjViOTQyZWRjMmUxIiwidCI6IjQ2ZmJlNmZkLTc4YWUtNDc2OS05YzFkLWJjZWE5NzM3OGFmNiJ9.

DISCUSSION

Our study of the distribution of healthcare workforce in England in relation to a simple indicator of population need confirms and extends the previous findings of Shaw and Dorling. In the past two decades, the distribution of the medical workforce in England continues to conform to the Inverse Care Law. Local authorities with a greater proportion of their population reporting poor self-rated health and long-term limiting illness are likely to have lower numbers of working medical professionals living there. Shaw and Dorling's Positive Care Law, whereby the provision of high amounts of unpaid informal care is very closely correlated with the prevalence of ill health, is shown to hold in 2011 and 2021. Nursing staff too appear to be positively distributed in relation to need, albeit less strongly. This is consistent with previous findings suggesting that the distribution of nurses and midwives across regions within several European countries do not follow the same pattern as physicians.[20] The most recent Census data, however, make clear that one pattern does not apply to all healthcare professional groups within the broad occupational

categories available in 2001. For example, the distributions of speech and language therapists and physiotherapists are very different from those of podiatrists and paramedics, despite all these professions being grouped under the umbrella of allied health professions.

Whilst Census data are a non-official data source for NHS workforce statistics[23] they nonetheless provide useful snapshots of self-reported data on those employed as health professionals irrespective of sector (e.g. public, private), setting (e.g. hospital, primary care) or employer (e.g. independent NHS contractor, agency). Unlike the interview-administered Annual Population Survey, Census data are collected by self-complete questionnaire which may lose the ability to clarify responses and reduce respondent error. The administration of the Census every 10 years prevents more detailed monitoring of trends in the distribution of healthcare professionals and changes to the format of questions and response options can limit direct comparisons between different Censuses. Despite this, we feel the classifications of ill health, broad occupational category, and informal care were sufficiently similar across the three Censuses that major changes in distribution would be evident.

Distance travelled to work and digital provision of remote healthcare are potentially important unmeasured confounders in the current analyses. No data were available for the current analysis to take account of those health professionals providing telehealth services to patients living in other local authorities. Patterns of commuting – notably across local authority boundaries from residences in areas of relatively low population ill health to workplaces in areas of higher need – would tend to reduce the inverse correlations observed. Data from Census 2021 for example suggest that 41% of medical professionals and 32% of nursing and midwifery professionals travel 10km or further to work. These data were reported in the week before 21 March 2021 when England was still emerging from its third COVID-19 lockdown and it is

possible the true figures may be higher. Our analyses at the level of Integrated Care Boards showed generally more favourable correlations than when measured at local authority level. Integrated Care Boards cover much larger geographical areas than local authorities, therefore tending to partially mitigate confounding by commuting. However, commuting patterns are unlikely to completely offset the apparent inequitable geographic distribution of some healthcare professional workforces. This could be tested in future studies with access to information both on place of residence and workplace for healthcare professionals.[33]

The availability of more detailed occupations in the latest Census was advantageous but we note that this still did not permit some important distinctions, such as between trainee, assistant/associate, and registered staff, or between each type of allied health professional (e.g. dieticians). The relatively short 7-day recall period for reporting occupation may selectively miss agency workers and it is important to note that data available in the Census are headcounts and not full-time equivalents.

Like Shaw and Dorling, we relied on a simple measure of population health need available from the same Census. A more sophisticated analysis of the equitable distribution of health professionals might seek measures of population health need specifically relevant to each professional group: a measure of child health to assess the distribution of child health nurses, mental health for mental health nurses, and so forth. Such measures were not available from the Census but future studies linking to other data sources may achieve this.

This study provides insights into the relative distribution of different healthcare professional groups but not on the adequacy of these levels of workforce provision nor the quality of services. Regions with the highest numbers of doctors per 1000 population in England may still be below the average rate in European Union

countries.[34,35] It is unclear to what extent the observed differences in the distribution between health professions that we have described in England will be found in other countries. The maldistribution of human resources for health is likely to be present to varying degrees in most countries and generalisability may be more likely for high-income countries with similar health systems, although the composition of health workforce, drivers at international, national and subnational levels may still differ in important ways.

Our study found evidence for persistent inequitable geographical distribution of healthcare workforces across England, but with substantial variation between different healthcare professional groups. Further research on the distinctive determinants of these different patterns and the extent to which commuting and digital health services mitigate these problems may help inform targeted interventions and profession-specific workforce planning.

AUTHOR STATEMENTS

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Contributors

Conceptualisation (GMP, AC), Methodology (AC, LQ, GMP), Data curation (AC, LQ), Formal analysis (AC, LQ), Visualisation (LQ), Project administration (AC), Supervision (GMP), Writing – original draft (AC), Writing – review and editing (AC, LQ, GMP)

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Competing interests

The authors have no competing interests to declare.

Ethical approval

This study used only publicly available, aggregated Census data. No ethical approval was required.

Data sharing statement

All data used in the current analyses are publicly available through the Office for National Statistics. Specifically, datasets used were:

2001 Census: KS001 - Usual resident population, ST016 - Sex and age by general health and limiting long-term illness, ST025 - Sex and age by general health and provision of unpaid care, ST116 - Employment activity and sex and professional qualifications by occupation, and C0822

2011 Census: KS102EW - Age structure, QS606EW - Occupation (Minor Groups), QS301EW - Provision of unpaid care, LC3302EW - Long-term health problem or disability by general health by sex by age, and CT1211_2011 Census – workplace table: occupation (4 digits) by age.

2021 Census: RM069 - Disability by general health by age, TS064 - Occupation - minor groups, TS007 - Age by single year, TS039 - Provision of unpaid care, and Occupations of those in employment, by local area, working pattern, employment status and disability status, England and Wales.

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Figure 1. The relationship between population with health need and health professionals, by year and broad health professional grouping (individual points are local authorities (London combined); figures are weighted correlation coefficients)

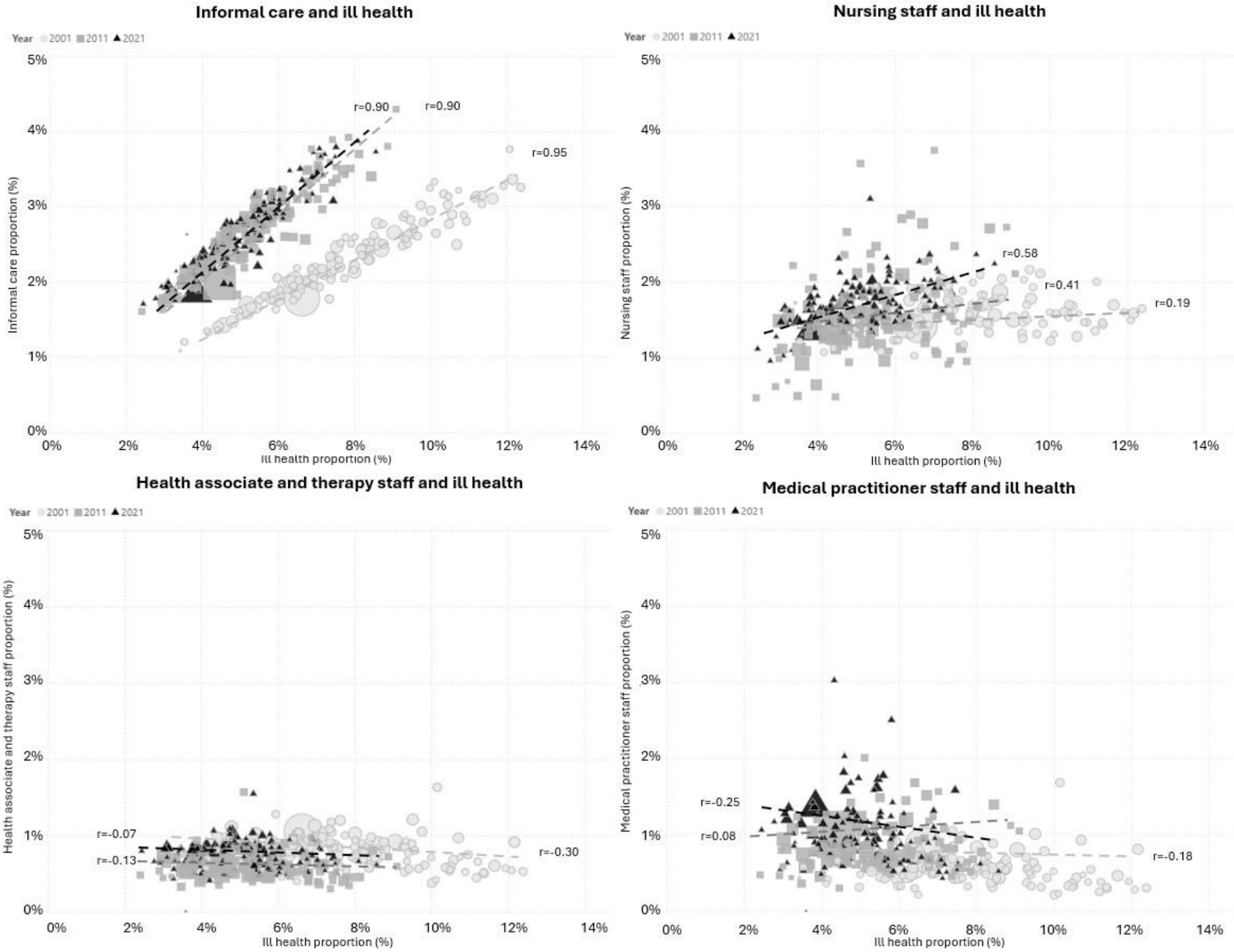

Table 1: Harmonised definition of ill health used in the current analyses

	Census 2001	Census 2011	Census 2021
Self-rated health			
Question wording	"Over the last twelve months would you say your health has on the whole been"	"How is your health in general?"	"How is your health in general?"
Response options	Good / Fairly good / **Not good**	Good / Fair / **Bad / Very bad**	Good / Fair / **Bad / Very bad**
	AND	*AND*	*AND*
Long-term limiting illness			
Question wording	"Do you have any long-term illness, health problem or disability which limits your daily activities or the work you can do?"	"Are your day-to-day activities limited because of a health problem or disability which has lasted, or is expected to last, at least 12 months?"	(a) "Do you have any physical or mental health conditions or illnesses lasting or expected to last 12 months or more?" (b) "Do any of your conditions or illnesses reduce your ability to carry out day-to-day activities?"
Response options	**Yes** / No	**Yes, limited a lot / Yes, limited a little** / No	(a) **Yes** / No (b) **Yes, a lot / Yes, a little** / Not at all
Ill health defined as the combination of bad self-rated health and long-term limiting illness (bold text) All data obtained from Nomis Explorer, official census and labour market statistics, Office for National Statistics.			

Table 2. Correlation of prevalence of ill health with proportion of population providing informal caring and working as a health professional (broad categories), across upper tier local authorities (London combined): England, 2001, 2011, and 2021

	Percentage of population			Weighted correlation (p value) with ill health			2021 - Weighted correlation (p value) with ill health				
	2001	2011	2021	2001	2011	2021	Young people	Older people	Ethnic minority	White British	Deprivation
Ill health†	7.42%	5.05%	4.77%	-	-	-	-	-	-	-	-
Informal caring (50+ hr / week)‡	2.16%	2.53%	2.49%	0.95 <0.001	0.90 <0.001	0.90 <0.001	0.90 <0.001	0.95 <0.001	0.86 <0.001	0.96 <0.001	0.88 <0.001
Nursing Staff§	1.58%	1.49%	1.64%	0.19 0.092	0.41 <0.001	0.58 <0.001	0.59 <0.001	0.54 <0.001	0.54 0.002	0.46 <0.001	0.68 <0.001
Health Associates and Therapy Professionals§	0.58%	0.60%	0.77%	-0.30 0.004	-0.13 0.305	-0.07 0.684	-0.27 0.25	-0.25 0.08	-0.16 0.48	-0.33 0.02	-0.29 0.03
Medical Practitioners§	0.63%	0.87%	1.10%	-0.18 0.131	0.08 0.535	-0.25 0.119	-0.12 0.58	-0.32 0.02	-0.05 0.81	-0.33 0.02	-0.24 0.18

† Defined as individuals self-reporting self-rated poor health *AND* long-term limiting illness (all ages)
‡ Percentage of population aged 5 years and over
§ Percentage of working age population (16-64 years)

Table 3. Correlation of prevalence of ill health with proportion of population providing working as a health professional (detailed groups), across upper tier local authorities (London combined): England, 2021, and Integrated Care Boards (ICB).

Health professional group	Local authority weighted correlation with ill health	Integrated Care Board (ICB) weighted correlation with ill health
Pharmaceutical technicians	0.774	0.888
Nursing auxiliaries and assistants	0.764	0.828
Care workers and home carers	0.746	0.733
Registered nurse practitioners	0.664	0.760
Registered mental health nurses	0.636	0.738
Other registered nursing professionals	0.523	0.530
Registered community nurses	0.479	0.671
Senior care workers	0.463	0.464
Dental nurses	0.366	0.524
Medical and dental technicians	0.309	0.473
Care escorts	0.264	0.232
Ambulance staff (excluding paramedics)	0.262	0.263
Podiatrists	0.242	0.459
Medical radiographers	0.199	0.432
Registered specialist nurses	0.195	0.369
Paramedics	0.108	0.181
Registered children's nurses	0.069	0.102
Occupational therapists	0.055	0.283
Other health professionals n.e.c.	-0.007	0.177
Health associate professionals n.e.c.	-0.008	0.006
Pharmacists	-0.008	0.422
Midwifery nurses	-0.075	0.288
Health care practice managers	-0.148	-0.109
Generalist medical practitioners	-0.208	-0.104
Physiotherapists	-0.283	-0.098
Specialist medical practitioners	-0.303	-0.175
Clinical psychologists	-0.362	-0.272
Health services and public health managers and directors	-0.367	-0.346
Dental practitioners	-0.386	-0.288
Speech and language therapists	-0.456	-0.408
Complementary health associate professionals	-0.478	-0.487
Psychotherapists and cognitive behaviour therapists	-0.558	-0.486
Other psychologists	-0.580	-0.576
Therapy professionals n.e.c.	-0.590	-0.586
n.e.c. not elsewhere classified		