International Journal of Population Data Science

Journal Website: www.ijpds.org

The Desirable Health Indicator: A New Indicator of Population Health and Healthcare utilisation

Harri Doel[1], Lucy J Griffiths[1], Rhodri D Johnson[1], Samantha Turner[1], Ronan A Lyons[1], and Jane Lyons[1*]

Submission History

Submitted:	15/05/2025
Accepted:	01/12/2025
Published:	23/02/2026

[1] Swansea University Medical School, Data Science Building, Singleton Park, Swansea, SA2 8PP

Abstract

Background and Objective

Healthcare research faces challenges in developing metrics that resonate with the general public or policymakers. We created a Desirable Health Indicator (DHI) to address this gap, centred around New Year's wishes for survival and non-occurrence of undesired events in the following year, for the population of Wales, UK, following discussions with policymakers and members of the public.

Methods

We created retrospective, population-based individual-level cohorts from linked routinely collected anonymised, health and demographic data from the Secure Anonymised Information Linkage (SAIL) Databank (2015-2022). The DHI was calculated per person per year and quantified the distribution of the population who survive calendar years and do not use selected health services (not admitted to hospital; no emergency department attendance; and not prescribed medication used in infection, analgesics, or mental health drugs). Group and individual interviews were held with members of the public and policy makers seeking their views of the indicator.

Results

The findings were understood and well received by members of the general public and policymakers. Between 2015 and 2019, the percentage of individuals meeting the DHI ranged between 39.6%-41.9%, increasing to 48.6% and 46.2% for2020 and 2021respectively, and reducing to 43.1% in 2022. Focussing on the year 2022, 1,154,630 (43.1%) met the DHI from a population of 2,677,829. The percentage of people with desirable health decreased significantly with age and with increasing socioeconomic deprivation. A higher proportion of males (49.2%) met the DHI compared to females (37.1%). Being male (aOR = 1.62 [95%CI 1.61,1.63]), 10-19 years of age (aOR = 1.69 [95%CI 1.68,1.71]), and living in the least deprived areas of Wales (aOR = 1.31 [95%CI 1.30,1.32]) were the characteristics associated with the highest odds of meeting the desirable health indicator. The most prevalent reasons for not meeting the indicator were GP prescriptions for drugs used in infections (29.5%), analgesics (22.8%) and mental health conditions (20.2%).

Conclusion

The DHI provides an insightful and novel tool for monitoring aspects of population health and healthcare utilisation. The DHI's coverage of important topics, derived from routine data sources, makes it a reproducible, temporally flexible, and easily understood indicator, suitable for informing policy development and addressing aspects of health inequalities. As data linkage capabilities expand internationally there are opportunities for implementation to aid comparison and better understanding of how systems perform.

Keywords

data linkage; administrative data; healthcare utilisation; population health

*Corresponding Author:
Email Address: J.Lyons@Swansea.ac.uk (Jane Lyons)

https://doi.org/10.23889/ijpds.v11i1.3005

Introduction

In recent years, a focus on population health and addressing health inequalities has become a major public health research priority area. Central to this endeavour is the use of health indicators, which serve as tools in assessing and monitoring the health statuses of populations. Health indicators include a mixture of statistics, measures health service utilisation, and surveys which often include reports on service utilisation and quality of life measures [1–3].

A 2021 systematic review reported the use of 691 health indicators covering 120 topics, most commonly using measures such as life expectancy, infant mortality, prevalence of obesity/overweight, mortality rates, behavioural issues, the presence of health conditions and healthcare utilisation [1].

Healthcare utilisation, a key measurable component of population health, plays a critical role in understanding health outcomes and access to healthcare services. The patterns of healthcare utilisation within a population not only reflect the distribution of health needs but can also shed light on inequalities in access to care [4, 5].

Health indicators also feature in broader societal developments that influence policy development. For example, good health and well-being, gender equality and reduced inequalities are three of the United Nations Sustainable Development Goals [6].

However, many health indicators suffer from a lack of available data which can inform policy development. Desirable qualities include ease of interpretation, sensitivity to policy changes, timeliness, historic time series, duality in measuring physical and mental health conditions, ability to be updated regularly, and disagreeability by population subgroups [2].

With these considerations in mind, and most notably the availability of population-wide routine data sources to fill gaps in the literature, we conceived a parsimonious, reproducible, temporally flexible, population-wide indicator which could be derived from routine data sources and would be easily understood by policymakers and the general public. The Desirable Health Indicator (DHI) was conceived at a European Information for Action (InfAct) meeting in 2014 on population health indicators but not fully implemented until 2024 by the Administrative Data Research Wales group [7, 8]. The concept arose during discussions concerning novel population health indicators that would reflect a positive view of health in line with the United Nations Sustainable Development Goals [6]. This led to scenario planning in which health was so well protected that few people became ill, and for those that did experience illness, primary care provided efficient and effective care. In such a scenario there would be little need for hospital or emergency care as these were viewed as system failures.

One of the rationales behind the indicator was to keep it as simple as possible in terms of data requirements in order to allow for replication in many different settings, including in those without general practice data but with access to dispensing data. General practice data is needed for measurement of the prevalence of many chronic conditions [9]. We did consider prescriptions for individual morbidities but did not include these as many medications have multiple uses. It is extremely difficult, if not impossible, to develop a one to one relationship between the medication and the illness, for example beta-blockers which can be used to treat angina, arrhythmias, hypertension and a variety of non-cardiac condition.

Many treatments for chronic diseases are at least partially effective and allow individuals to live lives without the need for emergency health care interventions. We consider that such people should also be candidates for meeting the DHI.

The DHI concept operationalised in this paper is based on the idea of what a person would wish for in the forthcoming year in terms of health. It comprises six sub-indicators including living for the entire year (i.e. survival), absence of hospital activity (inpatient and emergency department attendances), and absence of prescriptions for common conditions that people would wish to avoid (namely medication for infections, analgesics, or mental health conditions). The aim of this paper is to describe the creation of the DHI and describe its distribution in the population of Wales, UK. Such an indicator could be implemented in many countries as data linkage capabilities grow [10].

Methods

Study design

In this observational population-wide cohort study, we used anonymised and encrypted demographic, primary and secondary healthcare data held in the Secure Anonymised Information Linkage (SAIL) Databank to create an annual DHI for the population of Wales, UK (2015-2022) [11, 12]. Electronic health records (EHR) from primary and secondary care sources were used to examine healthcare service utilisation of study participants.

The desirable health indicator

The development of the indicator was discussed with the European Information for Action (InfAct) group on population health indicators in 2014, with a pilot project created using data in Wales; but not developed further due to lack of similar data in many countries. The concept was taken up again in 2024 by the Administrative Data Research Wales group [8].

Eliciting views of public and policy makers

We used semi-structured interviews to gather feedback on the indicator and the results [13].

The views of policymakers, public health agencies and members of the public were gathered at presentations to the Office of the Chief Medical Officer for Wales, the SAIL Consumer Panel, and the European Population Health Information Research Infrastructure (PHIRI) using group discussion and questions about ease of understanding, novelty, whether the findings were informative, any further developments, and desire to replicate in other settings in meetings from May to July 2024 [14]. In the meeting with the SAIL Consumer Panel the participants were provided with the results in advance and asked to consider the following questions prior to the meeting.

- Have you seen information like this presented before?
- Did you find the results easy to understand?
- Do you think most people would understand them?

- Did you find the results informative?
- What did you find most interesting?
- Have you any suggestions for improvement?

RAL gave the presentation and took notes of comments and questions raised. The meeting was also recorded by the Consumer Panel chair and issues summarised and presented to the team. Both sets of notes were studied to ensure all views were captured. Notes were kept from the meeting with the Chief Medical Officer and the PHIRI group.

In this study, we calculated he DHI annually for eight years (2015-2022) by identifying individuals who met the following six criteria: had a) survived the year, b) not been admitted to hospital, c) not had an Emergency Department (ED) attendance, d) not been prescribed drugs used in infections, e) not been prescribed analgesics and f) not been prescribed drugs used for mental health conditions.

Data sources

This study used routinely collected anonymised, individual-level, population-scale health and demographic data held in the SAIL Databank to create retrospective population-based individual-level linked cohorts [11, 12]. The study population along with their demographic and residency information was determined using the Welsh Demographic Service Dataset (WDSD), a list of all people registered to a Welsh General Practice (GP), in a free to use primary care National Health Service (NHS). The SAIL Databank currently receives data from 86% of the GPs in Wales, UK. The Welsh Longitudinal General Practice Dataset (WLGP) contains all GP events for individuals registered to a SAIL providing GP and was used to identify GP prescriptions using Read codes V2 [15] (S1). ED attendances were captured through the Emergency Department Dataset (EDDS) which contains all ED attendances (new attendances as well as planned and unplanned follow up appointments) across Wales. Hospital admissions were captured through the Patient Episode Dataset Wales (PEDW) which includes all hospital admissions, inclusive of day cases, for all NHS Wales hospitals as well as hospital admissions for Welsh residents treated at NHS England hospitals. Routine uncomplicated childbirth related admissions were not undesirable and hence did not contribute to the indicator (S1). Lastly, the Annual District Extract (ADDE) from the Office of National Statistics was employed to identify individuals who had died within the year.

Study population

We created eight population cohorts, one for each calendar year from 2015 to 2022. Cohorts were created to capture the population of Wales on the 1st of January of each year with follow up until residency break, death, or cohort end date which was the last day of each year. We restricted the study population to include individuals who had a full year of residency, and who were registered to a SAIL providing GP (86% of population) for accurate assessment of healthcare service use. Those who died within the year were also included to appropriately account for death.

Variables

We calculate the age of each individual on the 1st of January for every year of the study and grouped in intervals of 10 years i.e. 0-9, 10-19, . . . , 80-89, and 90 and above. Sex was recorded as male/female, and socioeconomic status was measured using the income deprivation quintiles of the Welsh Index of Multiple Deprivation (WIMD) 2019; an area-based Lower layer Super Output Area (LSOA) assigned measure of small area deprivation, which includes populations of approximately 1,600 individuals [16]. Due to possible changes in residency through house moves within a calendar year, we assigned each individual's socioeconomic status as the address where they had resided for the longest duration within that year, thereby reflecting the most prevalent location for each person.

Statistical analysis

Descriptive statistics were calculated for each year showing frequencies and percentages of individuals meeting the DHI and its sub-indicators with respect to each characteristic age group, sex, and deprivation quintiles. Binary logistic regression was used to measure the odds of meeting the desirable health indicator by age group, sex, and deprivation quintiles.

Ethics statement

The data in the SAIL Databank are anonymised using multi-party encryption of identifiers. The use of de-identified data in SAIL complies with the UK National Research Ethics Service (NRES) guidance and does not require individual-level consent. Applications to use data held within the SAIL Databank, an *ISO: 27001* and UK Statistics Authority (UKSA) Digital Economy Act (DEA) accredited Trusted Research Environment, must first be approved by the independent Information Governance Review Panel (IGRP). The IGRP contains a multidisciplinary professional group, including members of the public. It carefully considers each proposed project to ensure proper and appropriate use of SAIL data, including privacy protection (small numbers suppression) and research being in the public interest. When access has been granted, it is gained through a privacy-protecting safe haven and remote access system referred to as the SAIL Gateway. SAIL project 1650 was approved by IGRP on 19th September 2023. Participant consent was not required for this study as all data is anonymised and further encrypted.

Results

Figure 1 shows the number of people registered with Welsh GPs at the beginning of each year and the number who were in the 86% of GPs that supply data to SAIL.

Figure 2 shows the percentage of the population that met the DHI each year of the study period. Results for 2015 to 2019 are similar, with a marginal but gradual increase in the percentage of individuals meeting the DHI over this period. In 2015, 39.6% of the total population met the DHI, increasing slightly to 41.9% by 2019. The 2020 and 2021 in the figures were 48.6% and 46.2% respectively, reducing to 43.1% in 2022.

Figure 1: Study cohort inclusion rules and numbers per year

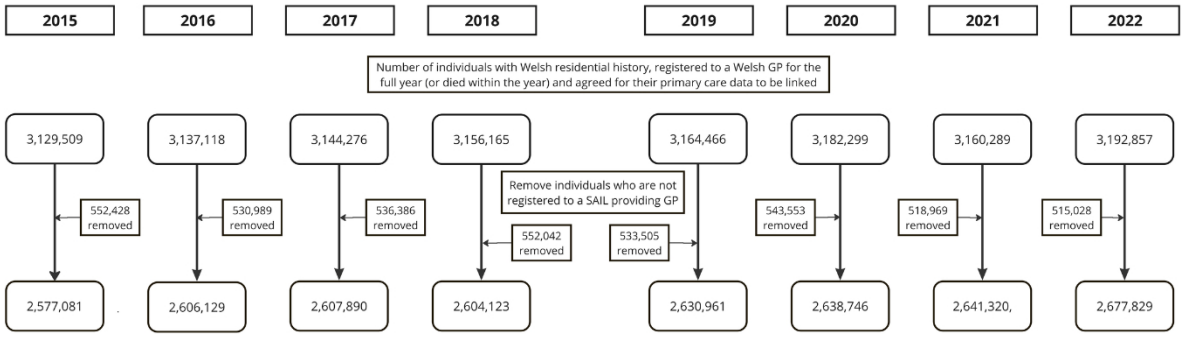
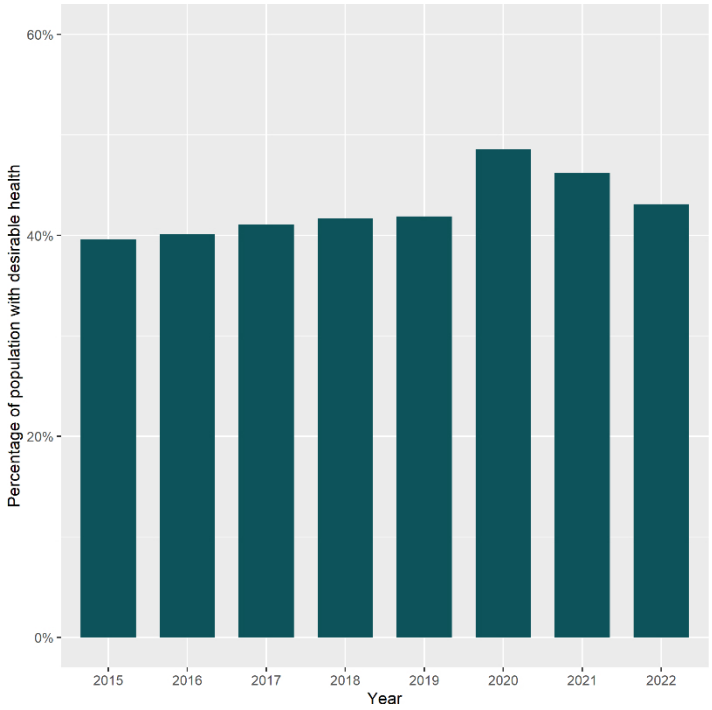


Figure 2: Percentage of the population that met the DHI over time (2015–2022)



Given the large number of results and small differences between years we focused on the year 2022 for the remainder of the analysis. Overall, 2,677,829 people were included in the analysis, with 1,154,630 (43.1%) identified as meeting the Desirable Health Indicator with 49.2% of males met the indicator compared to 37.1% of females. The highest percentage by age group was the 10–19 year-olds at 58.5% meeting the DHI, compared with 12.8% in the oldest age group (90+) (Table 1). Nearly half of the population who live in the least deprived (most affluent) areas of Wales met the indicator (47.2%), compared to 39.4% of individuals who live in the most deprived areas (Table 1).

Table 2 reports the univariate and multivariate logistic regression analysis results to measure the odds of meeting the DHI by the main effects: age group, sex, and deprivation quintiles. Being male (aOR=1.62, 95%CI = 1.61–1.63), aged 10-19 years (aOR = 1.69, 95%CI = 1.68–1.71), and living in the least deprived areas of Wales (aOR=1.31, 95%CI = 1.30–1.32) had the highest odds of meeting the DHI. Conversely, the oldest age group Wales had the lowest odds of meeting the DHI (aOR=0.18, 95%CI=0.17–0.19) and when looking at deprivation, those living in the most deprived areas of Wales had the lowest odds of meeting the DHI (aOR = 0.79, 95%CI = 0.78–0.80). S26 contains the multivariate logistic regression analysis results to measure the odds of meeting the desirable health indicator by the main effects with interactions.

The percentage of individuals meeting all six sub-domains of the DHI decreased with age and with increasing socioeconomic deprivation (Figure 3). Across all age categories, a higher percentage of males met the indicator, except for 0–9 year-olds (Figure 3). Similarly, across all age categories and both sexes, there was a higher percentage meeting the DHI in the least deprived areas. The demographic group with the highest percentage of individuals meeting the DHI (64.9%) were 20–29 year old males from the least deprived areas of Wales (Figure 3). Conversely, the demographic group with the lowest DHI percentage (9.02%) were the 90+ year old females living in the second most deprived areas of Wales (Figure 3).

In total, 1.15% of the 2022 cohort died, 12.5% had a hospital admission, 19% attended the emergency department,

Table 1: Distribution of population by demographic information and meeting the desirable health indicator (2022)

Demographic	Description	Total Population		Met DHI	
		N	%	N	% of Total
Total	NA	2,677,829	100.0%	1,154,630	43.1%
Sex	Male	1,334,198	49.8%	656,072	49.2%
	Female	1,343,631	50.2%	498,558	37.1%
Age group	0-9	274,729	10.3%	132,609	48.3%
	10-19	299,177	11.2%	174,892	58.5%
	20-29	309,723	11.6%	153,853	49.7%
	30-39	349,560	13.1%	162,991	46.6%
	40-49	325,052	12.1%	149,177	45.9%
	50-59	382,309	14.3%	157,601	41.2%
	60-69	323,996	12.1%	118,784	36.7%
	70-79	266,591	10.0%	78,239	29.3%
	80-89	121,172	4.53%	23,221	19.2%
	90+	25,520	0.95%	3,263	12.8%
WIMD income quintile	1. Most deprived	558,176	20.8%	219,680	39.4%
	2	538,368	20.1%	219,135	40.7%
	3	535,581	20.0%	234,779	43.8%
	4	507,352	18.9%	226,739	44.7%
	5. Least deprived	538,352	20.1%	254,297	47.2%

Table 2: Unadjusted and adjusted Odds Ratios (OR) and 95% confidence intervals (CI) regression analysis results measuring the odds of meeting the DHI by age group, sex, and deprivation quintiles

Characteristics	OR	95% CI		p-value	aOR	95% CI		p-value
Male	1.64	1.63	1.65	<0.001	1.62	1.61	1.63	<0.001
Age group 0-9	1.10	1.09	1.11	<0.001	1.12	1.11	1.14	<0.001
Age group 10-19	1.66	1.64	1.68	<0.001	1.69	1.68	1.71	<0.001
Age group 20-29	1.16	1.15	1.18	<0.001	1.18	1.17	1.19	<0.001
Age group 30-39	1.03	1.02	1.04	<0.001	1.05	1.04	1.06	<0.001
Age group 50-59	0.83	0.82	0.83	<0.001	0.82	0.81	0.83	<0.001
Age group 60-69	0.68	0.68	0.69	<0.001	0.67	0.67	0.68	<0.001
Age group 70-79	0.49	0.48	0.50	<0.001	0.48	0.47	0.48	<0.001
Age group 80-89	0.28	0.28	0.28	<0.001	0.28	0.27	0.28	<0.001
Age group 90+	0.17	0.17	0.18	<0.001	0.18	0.17	0.19	<0.001
Deprivation quintile1. Most deprived	0.86	0.86	0.87	<0.001	0.79	0.78	0.80	<0.001
Deprivation quintile2	0.91	0.90	0.92	<0.001	0.88	0.87	0.89	<0.001
Deprivation quintile4	1.12	1.11	1.13	<0.001	1.15	1.14	1.16	<0.001
Deprivation quintile5. Least deprived	1.27	1.26	1.28	<0.001	1.31	1.30	1.32	<0.001

29.5% were prescribed drugs used in infections, 22.8% were prescribed analgesics and 20.2% were prescribed drugs for mental health (Table 3). Across all socioeconomic groups prescriptions for drugs used in infections were the most common reason for not meeting the DHI (27.2-31.4%) (Table 3). For those aged below 40 years, prescriptions for drugs used in infections were the main cause, while prescriptions of analgesics were the most predominant among those aged 50-90+ (Table 3). In the age group 40-49 years, mental health prescriptions stood out as the most frequent reason for not meeting the DHI (48.3%). Prescriptions for drugs used in infections had the highest prevalence when looking at both sexes (Table 3).

Females exhibited a higher percentage of healthcare service utilisation compared to males (Figure 4). The percentage of people being admitted to hospital, being prescribed analgesics, and dying increased substantially with age (Figure 4b, 4e, 4a). Additionally, individuals from more deprived backgrounds attended emergency departments and received prescriptions for drugs used in infections, analgesics, and mental health more than those from the least deprived areas (Figure 4c, 4d, 4e, 4f). Results and figures for all other years (2015-2021) can be found in (S2-S25).

Figure 3: Desirable Health Indicator by age category, sex, and deprivation quintiles (2022)

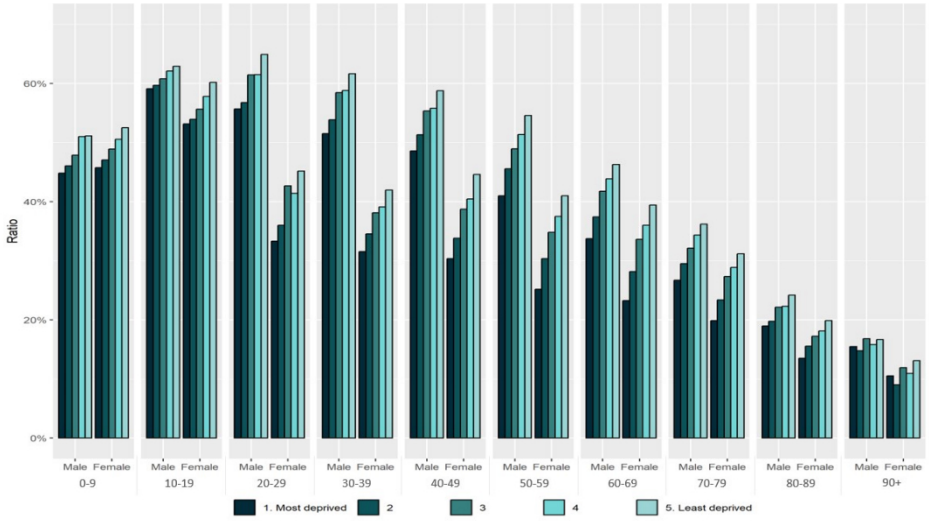


Table 3: Number and percentage of the population not meeting the DHI by sub-indicator, age, sex, and deprivation (2022)

Demographic	Description	Total population		Died		Hospital admission		Emergency department		Drugs used in infections		Analgesics		Mental health prescriptions	
		N	%	N	% of Total	N	% of Total	N	% of Total	N	% of Total	N	% of Total	N	% of Total
Total	NA	2,677,829	100.0%	30,843	1.15%	334,988	12.5%	507,540	19.0%	789,580	29.5%	610,066	22.8%	541,604	20.2%
Sex	Male	1,334,198	49.8%	15,327	1.15%	149,066	11.2%	252,016	18.9%	307,964	23.1%	260,814	19.5%	197,714	14.8%
	Female	1,343,631	50.2%	15,516	1.15%	185,922	13.8%	255,524	19.0%	481,616	35.8%	349,252	26.0%	343,890	25.6%
Age group	0-9	274,729	10.3%	34	0.01%	27,000	9.83%	68,600	25.0%	100,739	36.7%	9,929	3.61%	932	0.34%
	10-19	299,177	11.2%	40	0.01%	16,098	5.38%	64,241	21.5%	67,080	22.4%	13,793	4.61%	12,998	4.34%
	20-29	309,723	11.6%	124	0.04%	27,064	8.74%	60,091	19.4%	79,204	25.6%	34,169	11.0%	61,160	19.7%
	30-39	349,560	13.1%	338	0.10%	32,743	9.37%	60,633	17.3%	93,699	26.8%	58,939	16.9%	81,877	23.4%
	40-49	325,052	12.1%	757	0.23%	27,739	8.53%	49,881	15.3%	81,581	25.1%	73,235	22.5%	85,015	26.2%
	50-59	382,309	14.3%	1,800	0.47%	43,789	11.5%	57,526	15.0%	103,052	27.0%	111,603	29.2%	107,291	28.1%
	60-69	323,996	12.1%	3,703	1.14%	51,664	15.9%	50,245	15.5%	99,528	30.7%	114,390	35.3%	84,705	26.1%
	70-79	266,591	10.0%	7,897	2.96%	61,455	23.1%	51,517	19.3%	97,061	36.4%	113,138	42.4%	66,232	24.8%
	80-89	121,172	4.53%	10,421	8.60%	38,528	31.8%	35,295	29.1%	53,976	44.5%	65,138	53.8%	33,599	27.7%
	90+	25,520	0.95%	5,729	22.4%	8,908	34.9%	9,511	37.3%	13,660	53.5%	15,732	61.6%	7,795	30.5%
WIMD income quintile	1. Most deprived	558,176	20.8%	6,265	1.12%	71,151	12.7%	123,069	22.0%	175,245	31.4%	142,985	25.6%	133,862	24.0%
	2	538,368	20.1%	6,646	1.23%	69,388	12.9%	109,686	20.4%	166,465	30.9%	132,328	24.6%	120,440	22.4%
	3	535,581	20.0%	6,208	1.16%	66,678	12.4%	100,062	18.7%	156,156	29.2%	121,197	22.6%	103,658	19.4%
	4	507,352	18.9%	5,984	1.18%	64,098	12.6%	88,958	17.5%	145,265	28.6%	110,212	21.7%	93,514	18.4%
	5. Least deprived	538,352	20.1%	5,740	1.07%	63,673	11.8%	85,765	15.9%	146,449	27.2%	103,344	19.2%	90,130	16.7%

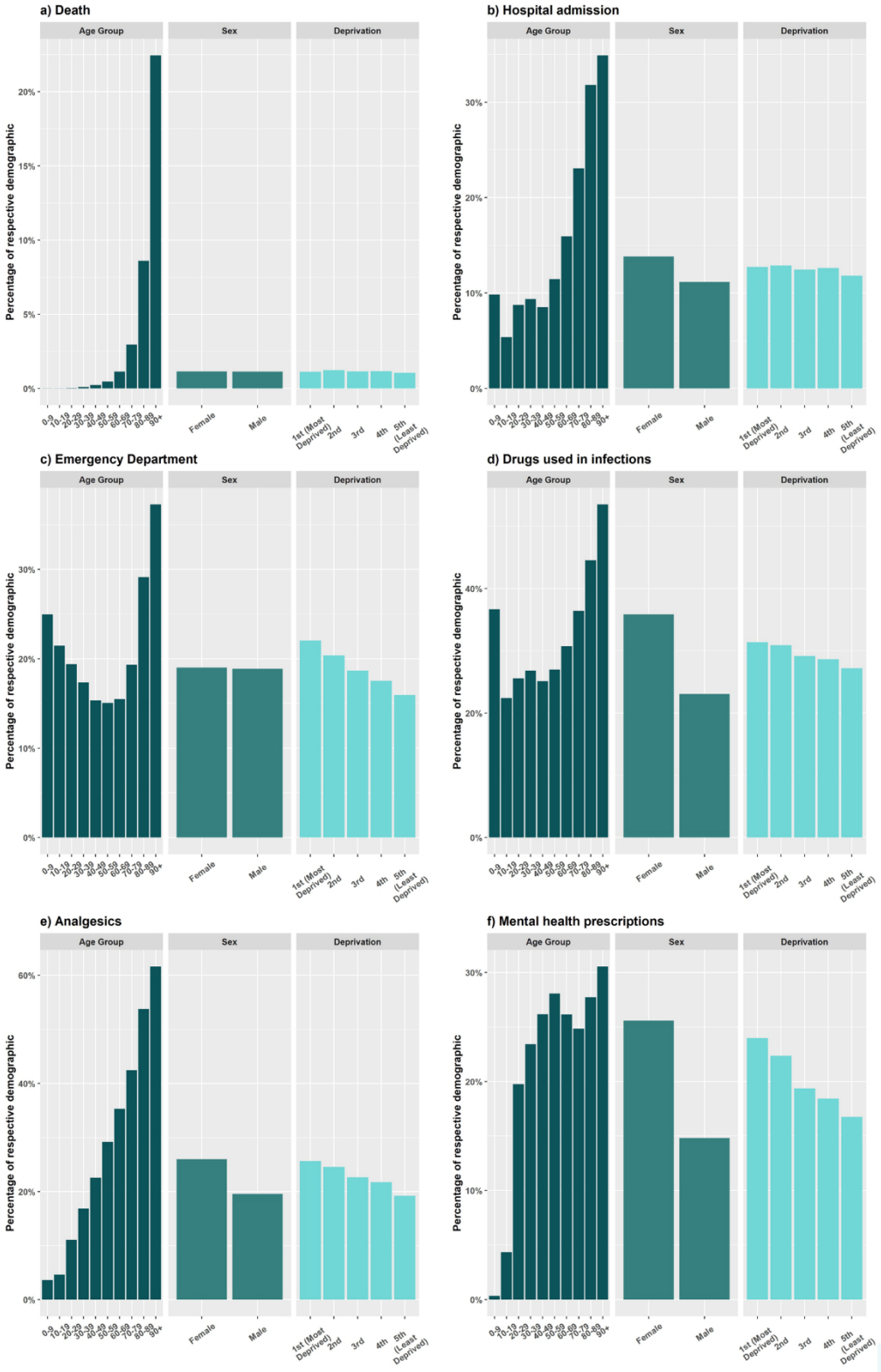
Highest percentage across all sub-indicators for each demographic row.

Feedback from policymakers, public health agencies and members of the public

The concept and results were shared with the Office of the Chief Medical Officer for Wales. The feedback was that the concept was very welcome with a request to examine how it could be implemented into national systems for health status reporting and to replicated across other UK countries.

The SAIL Consumer Panel consisting of 12 members of the public reported that they had not seen results presented like this before, found them easy to understand and were informative. They were surprised at how low the overall DHI percentage was in the population. They were supportive of its introduction and had some suggestions for improvement and further work: understanding and explaining the inequalities by deprivation group; expanding analyses to more groups of

Figure 4: Distribution of the population per sub-indicator presence by age, sex, and deprivation quintiles (2022)



people such as ethnic minorities and immunocompromised people; adding more layers of context, such as distinguishing reasons for attending the ED (injury vs medical problems); and conducting analysis by groups receiving one prescription versus multiple and by type of painkiller e.g. paracetamol, anti-inflammatories, and narcotics. Box 1 shows the written feedback from the chair of the Consumer Panel.

The PHIRI meeting was attended by eight individuals from Austria, Belgium, Croatia, Hungary, and Serbia. They were asked the same questions as the Consumer Panel with the addition of "Would you like to see such analyses for your country?"

They provided verbal and written feedback. The DHI was seen as a positive indicator focused on the healthy population,

Box 1: Feedback from the chair of the Consumer Panel.

- The findings were really interesting and extremely easy to understand.
- The charts were easy to read and not too complicated.
- The mental health component was surprising and members wondered how might this compare to the rest of Europe?
- Simple to understand but difficult topics to change, good to aim for.
- In time could refine analysis on what pain killers and mental health medicines were used.
- Some drugs for chronic diseases are so good it results in not needing pain killers and not regularly in hospital.
- If this was developed in the future it would be good to show the details of why people are going to A&E, by age group and the reasons for those admitted to hospitals.
- Is it possible to show ethnicity, disability, and its effects?
- It would be interesting to see further analysis by use of multiple pain killers, and multiple doses of antibiotics indicating ongoing problems.

unlike most others that focus on being unhealthy. All were very positive about the concept, none had seen an indicator like this before, all agreed that it would be easy to interpret by policymakers and the public. All expressed the view that they would like to see their national agencies calculate the DHI and share the data for comparative purposes and requested the detailed methodology to help them conduct the analyses.

Discussion

This study aimed to address the challenges of creating and effectively communicating population health metrics by introducing an easily interpretable indicator, the Desirable Health Indicator (DHI).

The study followed the health records of 2.6+million people over an 8-year period. Trends in DHI percentage were stable between 2015 and 2019 (39.6%-41.9%) with a notable increase across 2020 and 2021 during the height of the COVID-19 pandemic (48.6% and 46.2%), with a decrease in 2022 (43.1%) (Figure 2), consistent with published UK and international studies on the negative impact of the COVID-19 pandemic on healthcare service use and provision [17–20].

Focussing on results for 2022, less than half of the population (43.1%) met the criteria for the DHI (Table 1). In total, 1.15% of the total study population died in 2022, 12.5% had a hospital admission, 19% attended the emergency department, 29.5% were prescribed drugs used in infections, 22.8% were prescribed analgesics, and 20.2% were prescribed drugs for mental health (Table 3). When examining the differences demographic groups, males are more likely to meet the DHI (aOR = 1.62, 95%CI = 1.61-163) compared to females (Table 2). Across the sub-indicators, females are more likely to interact with health services (Figure 4, Table 3), and particularly to be prescribed treatment for mental health, painful conditions and infections. This is consistent with existing literature showing the prevalence or incidence of these conditions to be more common in this group [21–23].

Another potential explanation is the influence gender has on health seeking behaviour with females having consistently higher consultation rates [24, 25].

Failure to meet the DHI was substantially higher for people living in the most deprived areas (aOR = 0.79, 95%CI = 0.78-0.80) compared to those living in the least deprived areas (aOR=1.31, 95%CI = 1.30-1.32) (Figure 2 and Table 2). When combining age, sex, and area-based deprivation to examine outcomes in specific demographic groups, 20-29 year old males living in the least deprived area of Wales had the highest percentage of individuals who met the DHI (64.9%), compared to 9.02% of 90+ year old females living in the second most deprived areas who had the lowest percentage (Figure 2).

Individuals living in the least deprived areas consistently had a higher percentage of individuals who met the DHI (47.2%), contrasting with 39.4% in the most deprived fifth (Table 1, Figure 2). For the most deprived groups, there are higher percentages of prescriptions for analgesics, mental health drugs, and infections, a higher use of emergency departments but very similar percentages with hospital admissions (Table 3, Figure 4). A meta-analysis of 45 studies from 12 mostly western high-income countries, reported that chronic pain prevalence is found to be substantially higher in more deprived communities and individuals [26]. Likewise, existing literature shows much greater prevalence of mental health conditions in deprived areas and individuals [27, 28]. Our findings are consistent with the analysis of emergency department attendances by deprivation in England conducted by the Office of National Statistics [29]. The finding that hospital admissions were similar across deprivation fifths contrasts with some of the literature which reports higher rates in most deprived groups in England [30]. It should be noted that deprivation fifths are based on the Welsh Index of Multiple Deprivation and will have different cut-offs to the distribution of the Index of Multiple Deprivation in England [31].

The DHI was conceived as a parsimonious indicator that would be relatively easy to compute. It covers the range of conditions identified by the SIPHER (System science in Public Health and health Economics Research) desirable qualities of an indicator, which include easy interpretation, sensitivity to policy changes, timeliness, historic series, duality in measuring physical and mental health conditions, ability to be updated regularly, and disaggregation by population subgroups [2]. There are many specific conditions that could be included but the DHI includes metrics on mental and physical health and infection and hence covers many bases.

The concept behind the DHI was well received by policymakers, representatives of public health agencies across Europe, and members of the public. They reported that it gave them easy to understand and novel insights into population health with a desire to see implementation in multiple countries and suggested further work to add a deeper

understanding of the components which lead to failure to meet the DHI.

Members of the public would like to see further developments and analysis in relation to: understanding and explaining the inequalities by deprivation group; expanding analyses to more groups of people such as ethnic minorities and immunocompromised people; adding more layers of context, such as distinguishing reasons for attending the ED (injury vs medical problems); and conducting analysis by groups receiving one prescription versus multiple, and by type of painkiller e.g. paracetamol, anti-inflammatories and narcotics.

Following literature review and discussion with public health experts in PHIRI, the DHI appears to be a novel indicator. Most research on health service utilisation and health indicators tends to use metrics, such as age standardised rates per 100,000 for conditions, disability adjusted life years, life expectancy, and daily defined doses per 100,000 persons or consultations, for example the Healthy Belgium website [32]. These are helpful for comparisons between regions and across time and for public health experts, but do not immediately resonate with the public or many policymakers as the constructs are difficult to grasp for non-scientific audiences. One of the key strengths of the DHI is its simplicity as a reproducible, population-wide, and easily understood health indicator.

The individual components of the DHI or their proxies have been well studied in the literature but not assembled as an indicator. There are many studies and websites that compare mortality, hospital admissions, emergency department attendances and measurements of prescribing for antibiotics, mental health conditions and pain but report using different metrics, such as daily defined doses (DDD) per 1000 persons per day for antibiotic prescribing or per consultation. The DHI sub-indicator is on prescribing for all infections and hence wider than antibiotics prescribing, whereas DDD metrics include repeat prescriptions per individual and differing defined doses per drug, limiting comparability.

Among the strengths of the study is the ability to link multiple anonymised demographics, longitudinal primary and secondary healthcare, and mortality data for the population of Wales, UK through the SAIL Databank, creating very large, population representative studies, with outcomes recorded in different datasets [11, 12].

Whilst our study has provided important findings, several limitations need to be considered. The DHI was designed to be parsimonious and easy to implement for jurisdictions with limited data assets. It could be criticised and in that it does not contain a comprehensive list of health conditions but deciding on which health conditions to include is not an easy task.

General practice data is needed for measurement of the prevalence of many chronic conditions [9]. We did consider prescriptions for individual morbidities but did not include these as many medications have multiple uses. It is extremely difficult, if not impossible, to develop a one to one relationship between the medication and the illness, for example beta-blockers which can be used to treat angina, arrhythmias, hypertension and a variety of non-cardiac condition.

Many treatments for chronic diseases are at least partially effective and allow individuals to live lives without the need for emergency health care interventions. We consider that such people should also be candidates for meeting the DHI.

It should be noted that the DHI resonated well with policymakers and members of the general public. The DHI is not a direct measure of health, it measures aspects of health and indications of likely absence of conditions that are usually treated with prescriptions. It will also be influenced by issues such as personal resilience, health seeking behaviours, how clinicians manage conditions, and patterns of health service provision. Additionally, this indicator utilises data held in the SAIL Databank which contains 86% of Welsh GP data and so whilst this is intended as a population-wide indicator, it does not yet cover the complete population. However, analysis has shown small differences between participating and non-participating practice populations that do not bias the findings [33]. A further limitation is that our analysis of prescribing is limited to general practice issued scripts as electronic hospital prescribing has not yet been rolled out nationally. Some 70% of antibiotics are prescribed by GPs in the UK. However, many prescribed antibiotics in hospital are likely to have also prescriptions from GPs, limiting this bias [34]. Finally, this indicator has been developed on anonymised NHS data, SAIL does not contain private health records and so any private prescriptions or elective operations in private hospitals are not included. Private healthcare use in lower in Wales due to the free to use NHS system [35].

Future work will include considering the recommendations of the members of the public listed above. Permission has been given to incorporate Census 2021 data into the DHI to include outputs on demographic and protected characteristics such as ethnicity, gender identity, and disability as well as socioeconomic status. We are also seeking access to a dispensing database that covers 100% of the population and to datasets with measures of income and benefits to conduct analysis of household and individual level socioeconomic status. Additionally, with other population-wide linked data systems available, we would like to compare the Welsh results with other nations or populations. The method has been shared with the European PHIRI group to aid dissemination and replication. We will also use longitudinal data to develop predictive modes forecasting the Desirable Health Indicator and its components in subsequent years.

Implementation of the DHI across various settings and jurisdictions, providing accessible and comparable data, will offer an interesting insight into variation by healthcare systems and opportunities to gain insight into underlying reasons. Being able to calculate the DHI by various subgroups of the population highlights disparities in outcomes between patient groups and helps identify groups for improved policies and intervention. For example, the high proportion of the public being treated with mental health drugs is not an indication that prescribing for mental health problems should stop but an indication that there are serious problems with mental health in a population that have not been adequately addressed by current policies.

In conclusion, this study has made significant strides in bridging the gap between population metrics and public understanding by introducing the DHI as an innovative, accessible, and comparable indicator of population health and healthcare utilisation. We demonstrate that this indicator provides clear insights into healthcare service utilisation patterns in Wales, specifically examining variations across socioeconomic status, sex, and age groups. Moving

forward, informing policymakers and the public about healthcare utilisation patterns can facilitate evidence-based decision making and resource allocation. Research into the determinants of healthcare utilisation will help identify key factors driving disparities and inform targeted interventions. Furthermore, evaluating the effectiveness of embedded interventions aimed at reducing the undesirable use of healthcare systems can guide efforts to improve their efficiency and equity.

Acknowledgements

This study makes use of anonymised data held in the Secure Anonymised Information Linkage (SAIL) Databank. We would like to acknowledge all the data providers and people who make anonymised data available for research. The authors would like to extend their gratitude and acknowledgement to the NHS, the SAIL Consumer Panel as well as the IGRP who approved this project (SAIL project 1650). We are also indebted to the policymakers and the European INFACT and PHIRI groups who contributed to the development of the DHI.

Contributors

JL, RAL and LJG conceived and designed the study. HD and JL had full access to all data used in this study. Due to data permission restrictions, not all authors were able to access the underlying data used in the study. HD checked and verified the data used in the analysis and conducted the analysis in consultation with JL. HD wrote the original draft. JL, RAL, LG, RJ, and ST reviewed, edited, and approved the final manuscript. All authors were responsible for submitting the article for publication.

Funding

This work is supported by Administrative Data Research (ADR) Wales (Grant ref: ES/W012227/1), part of the ADR UK investment, uniting research expertise from Swansea University Medical School and WISERD (Wales Institute of Social and Economic Research and Data) at Cardiff University with analysts from Welsh Government. ADR UK is funded by the Economic and Social Research Council (ESRC), part of UK Research and Innovation.

Competing interest

The authors declare no conflict of interest.

Patient consent for publication

Not required.

Ethical approval

The use of deidentified data in SAIL complies with National Research Ethics Service (NRES) guidance. Applications to use data held within the SAIL Databank, an ISO: 27001 and UK Statistics Authority (UKSA) Digital Economy Act (DEA) accredited Trusted Research Environment, must first be approved by the independent Information Governance Review Panel (IGRP). This panel contains individuals with expertise in data governance and protection, including the Chair of the Wales NRES Committee, Caldicott Guardians and members of the public. The IGRP approved SAIL project 1650 on 19th September 2023.

Data availability

This study makes use of anonymised, individual-level data held in the SAIL Databank, a Trusted Research Environment, at Swansea University, Swansea, UK. Due to the nature and level of the data, data are not publicly available. All proposals to use SAIL data are subject to review by the independent IGRP. The IGRP gives careful consideration to each project proposal to ensure proper and appropriate use of SAIL data. If a project is approved, access to the requested data is gained through a privacy-protecting safe haven and remote access system referred to as the SAIL Gateway. SAIL has established an application process to be followed by anyone who would like to access data via SAIL at: https://www.saildatabank.com/application-process/.

References

1. Albert-Ballestar S, García-Altés A. 1658135411Measuring health inequalities: a systematic review of widely used indicators and topics. Int J Equity Health. 2021 Dec 10;20(1):73.

2. Angus C, Meier P. Choosing the SIPHER health indicators [Internet]. 2022 Jan [cited 2024 Apr 30]. Available from: https://doi.org/10.36399/gla.pubs.310976

3. European Commission. European Commission. [cited 2024 May 8]. European Core Health Indicators (ECHI). Available from: https://health.ec.europa.eu/indicators-and-data/european-core-health-indicators-echi/echi-european-core-health-indicators_en#health-interventions-health-promotion

4. Marmot M, Allen J, Boyce T, Goldblatt P, Morrison J. Health Equity in England: The Marmot Review 10 Years On. Institute of Health Equity [Internet]. 2022 [cited 2024 Apr 30]. Available from: https://www.health.org.uk/publications/reports/the-marmot-review-10-years-on.

5. World Health Organization. Monitoring Health Inequities: An Essential Step for Achieving Health Equity [Internet]. World Health Organization. 2015 [cited 2024 Apr 30]. Available from: https://www.who.int/publications/i/item/who-his-hsi-2015-1.

6. United Nations. United Nations. [cited 2024 May 8]. Sustainable Development Goals (SDGs). Available from: https://sdgs.un.org/goals#icons

7. InfAct (Information for Action). InfAct (Information for Action) [Internet]. [cited 2024 May 17]. Available from: https://www.inf-act.eu/.

8. Administrative Data Research Wales (ADR) [Internet]. [cited 2024 Jul 3]. Available from: https://adrwales.org/.

9. MacRae C, Morales D, Mercer S, Lone N, Lawson A, Jefferson E, McAllister D, van der Akker M, Marshall A, Seth S, Rawlings A, Lyons J, Lyons RA, Mizen A, Abubaker E, Dibben C, Guthrie B, Impact of data source on multimorbidity measurement: a comparative study of 2.3 million individuals in the Welsh national health service. BMC Med 21, 309 (2023). https://doi.org/10.1186/s12916-023-02970-z

10. European Observatory on Health Systems and Policies. Health and Care Data: Approaches to data linkage for evidence-informed policy [Internet]. 2nd ed. Polin K, Panteli D, Webb E, editors. Vol. 25. World Health Organisation; [cited 2024 Jun 4]. Available from: https://eurohealthobservatory.who.int/publications/i/health-and-care-data-approaches-to-data-linkage-for-evidence-informed-policy.

11. Lyons RA, Jones KH, John G, Brooks CJ, Verplancke JP, Ford D V, et al. The SAIL databank: linking multiple health and social care datasets. BMC Med Inform Decis Mak [Internet]. 2009 Dec 16 [cited 2024 Apr 30];9(1):3. Available from: https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/1472-6947-9-3.

12. Ford D V, Jones KH, Verplancke JP, Lyons RA, John G, Brown G, et al. The SAIL Databank: building a national architecture for e-health research and evaluation. BMC Health Serv Res [Internet]. 2009 Dec 4 [cited 2024 Apr 30];9(1):157. Available from: https://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-9-157.

13. DeJonckheere M, Vaughn LM. Semistructured interviewing in primary care research: A balance of relationship and rigour. Family Medicine and Community Health. 2019 Mar;7(2). https://doi.org/10.1136/fmch-2018-000057

14. SAIL Databank Consumer Panel [Internet]. [cited 2024 Jul 3]. Available from: https://saildatabank.com/governance/approvals-public-engagement/consumer-panel/.

15. NHS England. Read Codes [Internet]. [cited 2024 Jul 23]. Available from: https://digital.nhs.uk/services/terminology-and-classifications/read-codes#:~:text=Read%20Codes%20are%20a%20coded,3%20(CTV3%20or%20v3).

16. Welsh Government. Welsh Government. 2024 [cited 2024 Apr 30]. Welsh Index of Multiple Deprivation: Index Guidance. Available from: https://www.gov.wales/welsh-index-multiple-deprivation-index-guidance.

17. Howarth A, Munro M, Theodorou A, Mills PR. Trends in healthcare utilisation during COVID-19: a longitudinal study from the UK. BMJ Open [Internet]. 2021 Jul 30 [cited 2024 Apr 30];11(7):e048151. Available from: https://bmjopen.bmj.com/content/11/7/e048151

18. Moynihan R, Sanders S, Michaleff ZA, Scott AM, Clark J, To EJ, et al. Impact of COVID-19 pandemic on utilisation of healthcare services: a systematic review. BMJ Open [Internet]. 2021 Mar 16 [cited 2024 Apr 30];11(3):e045343. Available from: https://bmjopen.bmj.com/content/11/3/e045343

19. Taxiarchi VP, Senior M, Ashcroft DM, Carr MJ, Hope H, Hotopf M, et al. Changes to healthcare utilisation and symptoms for common mental health problems over the first 21 months of the COVID-19 pandemic: parallel analyses of electronic health records and survey data in England. The Lancet Regional Health - Europe [Internet]. 2023 Sep [cited 2024 Apr 30];32:100697. Available from: https://doi.org/10.1016/j.lanepe.2023.100697

20. Williams R, Jenkins DA, Ashcroft DM, Brown B, Campbell S, Carr MJ, et al. Diagnosis of physical and mental health conditions in primary care during the COVID-19 pandemic: a retrospective cohort study. Lancet Public Health [Internet]. 2020 Oct [cited 2024 Apr 30];5(10):e543–50. Available from: https://doi.org/10.1016/S2468-2667(20)30201-2

21. Seedat S, Scott KM, Angermeyer MC, Berglund P, Bromet EJ, Brugha TS, et al. Cross-national associations between gender and mental disorders in the World Health Organization World Mental Health Surveys. Archives of General Psychiatry. 2009 Jul 1;66(7):785. https://doi.org/10.1001/archgenpsychiatry.2009.36

22. Tschon M, Contartese D, Pagani S, Borsari V, Fini M. Gender and sex are key determinants in osteoarthritis not only confounding variables. A systematic review of Clinical Data. Journal of Clinical Medicine. 2021 Jul 19;10(14):3178. https://doi.org/10.3390/jcm10143178

23. Smith DR, Dolk FC, Smieszek T, Robotham JV, Pouwels KB. Understanding the gender gap in antibiotic prescribing: A cross-sectional analysis of English primary care. BMJ Open. 2018 Feb;8(2). https://doi.org/10.1136/bmjopen-2017-020203

24. Thompson AE, Anisimowicz Y, Miedema B, Hogg W, Wodchis WP, Aubrey-Bassler K. The influence of gender and other patient characteristics on health care-seeking behaviour: A QUALICOPC study. BMC Family Practice. 2016 Mar 31;17(1). https://doi.org/10.1186/s12875-016-0440-0

25. Harris MG, Baxter AJ, Reavley N, Diminic S, Pirkis J, Whiteford HA. Gender-related patterns and determinants of recent help-seeking for past-year affective, anxiety and substance use disorders: Findings from a National Epidemiological Survey. Epidemiology and Psychiatric Sciences. 2015 Oct 2;25(6):548–61. https://doi.org/10.1017/s2045796015000876

26. Prego-Domínguez J, Khazaeipour Z, Mallah N, Takkouche B. Socioeconomic status and occurrence of chronic pain: a meta-analysis. Rheumatology. 2021 Mar 2;60(3):1091–105.

27. Grigoroglou C, Munford L, Webb RT, Kapur N, Ashcroft DM, Kontopantelis E. Prevalence of mental illness in primary care and its association with deprivation and social fragmentation at the small-area level in England. Psychol Med. 2020 Jan 12;50(2):293–302.

28. Remes O, Lafortune L, Wainwright N, Surtees P, Khaw KT, Brayne C. Association between area deprivation and major depressive disorder in British men and women: a cohort study. BMJ Open. 2019 Nov 25;9(11):e027530.

29. Office for National Statistics (ONS). ONS website. 2023 [cited 2024 Jun 20]. Inequalities in Accident and Emergency department attendance, England: March 2021 to March 2022. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthcaresystem/articles/inequalitiesinaccidentandemergencydepartmentattendanceengland/march2021tomarch2022#:~:text=The%20odds%20of%20attending%20A%26E%20for%20the%20most%20acute%20of,of%20areas%20(decile%201).

30. Luben R, Hayat S, Khawaja A, Wareham N, Pharoah PP, Khaw KT. Residential area deprivation and risk of subsequent hospital admission in a British population: the EPIC-Norfolk cohort. BMJ Open. 2019 Dec 16;9(12):e031251.

31. Asaria M, Doran T, Cookson R. The costs of inequality: whole-population modelling study of lifetime inpatient hospital costs in the English National Health Service by level of neighbourhood deprivation. J Epidemiol Community Health (1978). 2016 Oct;70(10):990–6.

32. Healthy Belgium [Internet]. [cited 2024 Jul 3]. Available from: https://www.healthybelgium.be/en/.

33. Jalali-najafabadi F, Bailey R, Lyons J, Akbari A, Ba Dhafari T, Azadbakht N, et al. 10-year multimorbidity patterns among people with and without rheumatic and musculoskeletal diseases: an observational cohort study using linked electronic health records from Wales, UK. BMJ Open. 2024 Jun 19;14(6):e079169.

34. National Institute for Health and care Research. How to reduce antibiotic use in primary care . 2024 Feb.

35. Patients drift towards paying for hospital care out of their own pocket across all four UK countries [Internet]. [cited 2025 Sept 18]. Available from: https://www.nuffieldtrust.org.uk/news-item/patients-drift-towards-paying-for-hospital-care-out-of-their-own-pocket-across-all-four-uk-countries#:~:text=Calculations%20by%20the%20Nuffield%20Trust,20%25%20from%2045%2C000%20to%2054%2C000.