Medical Research Archives

European Society of Medicine

OPEN ACCESS

Published: September 30, 2023

Citation: Magomedova, A., 2023. The analysis of the main contributing factors for the increasing trend of Diabetes Type 2, diabetes morbidity and mortality trends in England, 2017-2022. Medical Research Archives, [online] 11(9). https://doi.org/10.18103/mra.v11i9.4403.

DOI: https://doi.org/10.18103/mra.v11i9.4403

ISSN: 2375-1924

RESEARCH ARTICLE

The analysis of the main contributing factors for the increasing trend of Diabetes Type 2, diabetes morbidity and mortality trends in England, 2017-2022.

Anzhelika Magomedova

University of Essex, Wivenhoe Park, Colchester, UK, CO4 3SQ.

anjelika437@gmail.com

ABSTRACT

Background and aim: Diabetes Type 2 is a non-communicable disease which is characterized by chronic hyperglycaemia and disruption of metabolism. A poor management of diabetes leads to serious cardiovascular and neural complications. The prevalence of Diabetes Type 2 is increasing globally; in the United Kingdom, the number of people living with a diabetes increased by more than 100,000 from 2018 to 2019[1]. In 2019, 3,9 million people had diagnosis of diabetes, and predictions are that this number will increase to 5,3 million in 2025. The aim of this research is to examine the main contributing factors and their influence on the prevalence of Diabetes Type 2 among people aged 17+ in England based on the routine epidemiological data for 2017-2022 years. Additionally, this research will analyze trends for hospital admissions with the diagnosis of Diabetes Type 2 and diabetes mortality statistics.

Methods: The Pearson's and the Spearman's correlation analyses are used to investigate possible associations, their strength, monotonicity and direction between the prevalence of diabetes, deprivation, low physical activity, obesity and density of fast food outlets. Stratified random sampling of 153 England counties & unitary authorities (the division of 2017) are used for the statistical analysis. A comparative analysis is used to analyze trends for hospital admissions with the diagnosis Diabetes Type 2 and diabetes mortality statistics. Descriptive statistics and quantitative analysis of secondary routine numerical data collected by the National Health Service Digital, the National Health Survey and the Office for Health Improvement & Disparities is used.

Findings: The analysis revealed positive correlations between the prevalence of diabetes and indicators of deprivation, obesity, low physical activity. In general, diabetes, obesity and physically inactive adults are more prevalent in counties with higher deprivation score. The strong positive correlation was found between density of fast food outlets and deprivation; the analysis of mean values indicated a positive linear relationships between obesity, diabetes indicators and density of fast food outlets. The comparative analysis revealed an upward trend for both, hospital admissions with the diagnosis Diabetes Type 2 and diabetes mortality.

Conclusion: In conclusion, analysis based on 80 counties & unitary authorities of England indicated that the main contributing factors for the increasing trend of Diabetes Type 2 can be the increasing prevalence of overweight and obese adults, low physical activity and deprivation. Additionally, the analysis demonstrated that the availability and abundance of fast food outlets, especially in more deprived deciles of England are closely associated with obesity and indirectly with the prevalence of Diabetes Type 2. Additionally, an increasing trend in the prevalence of Diabetes Type 2 is accompanied by a similar growth of hospital admissions with the diagnosis of Diabetes Type 2 and diabetes mortality.

Keywords: Diabetes mellitus, Diabetes Type 2, Obesity, Global Health.

1. Introduction

Diabetes has become the ninth leading cause of death: from 2000 to 2019 deaths from diabetes increased by 70% worldwide. A global prevalence of Diabetes Mellitus was estimated at 8,5% in 2014 and increased to 9,3% in 2019[2,3]. The new cases of diabetes show an upward trend globally; the diabetes global increasing trend can be observed through decades: from 108 million in 1908 to 463 million in 2019[2,3].

Diabetes is a leading cause of disability which results in a substantial financial burden imposed on health systems globally[2]. For example, UK only spends 8,8 billion pounds annually in a direct cost, and about 13 billion in indirect costs on complicated Diabetes Type 2 (T2D)[1, 4]. Diabetes is a primary cause of blindness, myocardial infarction, stroke, kidney failure and feet amputations; in the analysis of mortality rates from 2004 to 2019, diabetes accounted for 40000 excess deaths in people with diabetes as compared to general population[5].

The increase in prevalence of diabetes can be observed in almost all countries with increasing numbers particularly in middle- and high-income countries. Around 90% of people with diabetes have T2D which is a major cause of premature mortality, with around 22,000 people with diabetes dying early each year in England[1, 6, 7].

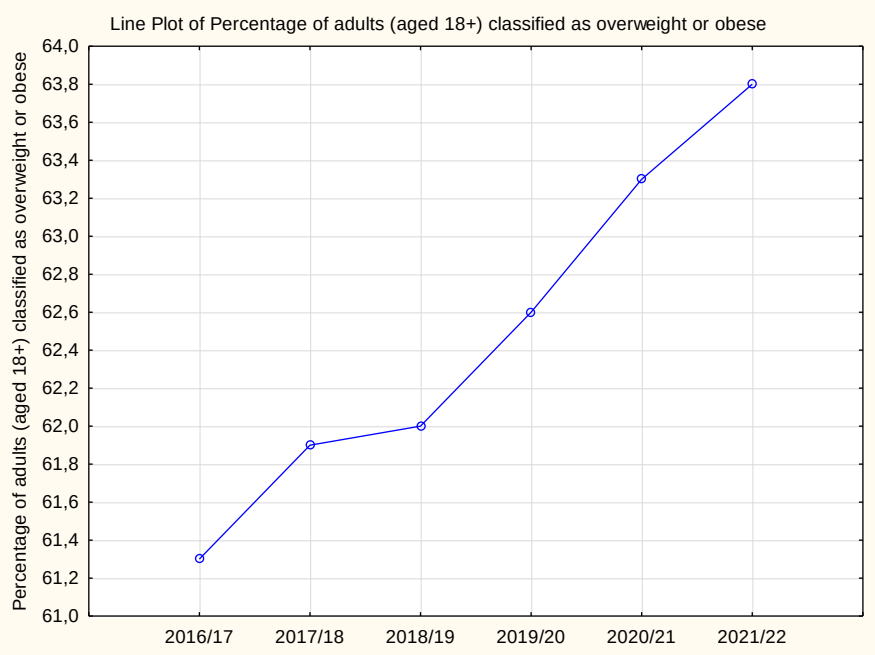
T2D is closely associated with obesity and unhealthy lifestyle choices; obesity (BMI higher than 25) is identified as a main prerequisite and a risk factor of T2D[6]. However, the main determinants and risk factors of T2D are not limited to personal food preferences, the obesogenic environment and deprivation can also contribute to the development of the disease[7,8,9].

The aim of this research is to analyze the main contributing factors for the increasing trend in the prevalence of Diabetes Type 2; examine the trends for hospital admissions with the diagnosis of T2D and mortality from diabetes among population aged 17+ in England from 2017 to 2022.

THE SCALE OF THE PROBLEM:

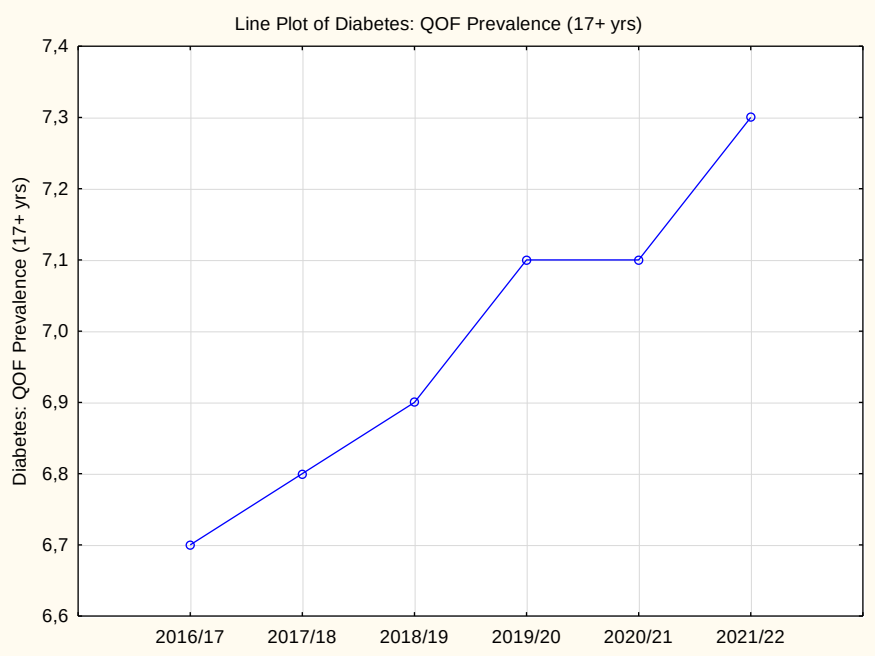
According to the latest statistical data, there are around 3.9 million people with T2D in England with around 200000 new cases every year which accounts for 3.5% of incidence proportion (200000/57466126= 3,5%-1000 crude rate)[1,10,11]. The two main indicators for obesity and diabetes prevalence in England reflect a steady growth in number of people suffered from diabetes and obesity (Figure 1,2).

Figure 1. Line plot for the Percentage of adults classified as overweight or obese.



Author used data from fingertips. phe.org.uk.

Figure 2. Line plot of Diabetes: QOF Prevalence (17 + yrs)



Author used data from fingertips. phe.org.uk.

The prevalence of T2D in England is 8,5%[12,13]. T2D is not distributed equally in terms of gender, age, ethnicity and socio-economic group, being more prevalent in deprived areas, lower socio-economic groups, South Asian, African and Caribbean ethnic groups, among people older than 40 or 25 in black community and ethnic minorities, people with a family history of T2D and overweight or obese people with a BMI higher than 25[1,14].

The highest percentage is observed in the 40-79 age group (data for 2020-2021: Under 40-4,1%, 40-64- 43,3%, 65-79-37,7%, 80 and over-14,9%). The prevalence declined after the age 80, mostly because of decreased survival at this age[1]. The prevalence of T2D examined from 2017 to 2022, showed an upward trend across England and the projection made by the Public Health England is that this figure will rise significantly from 2020 to 2030[9].

The existed research on the topic includes the epidemiological research of Kelly West (1978) who was the first to establish a causal relationship of obesity and T2D. In his 30-year study, West identified that the increasing rates of obesity are associated with the increasing rates of T2D, which in turn are linked with increasing rates of cardiovascular disease (CVD). West stated that T2D is preventable, because pre-diabetes stage can be readily identified before the onset of disease and changes in lifestyle can prevent the disease[15].

Another extensive cohort study which contributes to the increased knowledge about T2D is the Framingham Heart Study. A longitudinal cohort study of CVD revealed that the prevalence of obesity increased from a few percent in 1970 to 25-30% in 1990 in both sexes. A similar trend occurred in the prevalence of T2D and CVD; an almost entire rise in diabetes happened in individuals with obesity replicating the findings of West K[16].

A study of Lusignan, (2005) based on the UK primary care database - Doctors' Independent Network, retrieved data from 74 practices that had continuous recording from 1994 to 2001; the results demonstrated decrease in the percentage of those having BMI lower than 25kg/m2 (from 27,1 in 1994 to 19,4% in 2001) and an increase in the prevalence of T2D and obesity among diabetic population[17]. Another study of Holman, (2011) used data from Health Survey for England 2003-2008 to estimate total prevalence of diabetes and projected diabetes prevalence. The results showed that total prevalence of diabetes will rise from 7,4% in 2010 to 9,5% in 2030. This increase is attributed mainly to rising prevalence of obesity, changing age and ethnic group structure of the population[18]. The study of Imkampe,(2011) presented analysis of repeated cross-sectional surveys in England for 1994, 1998, 2003, 2006. The results indicated that increasing prevalence of T2D has been associated with an increase in socio-economic inequality in women, but not men[19].

In terms of T2D main risk factors and determinants, several studies showed consistent positive interrelations of obesity, T2D, deprivation and fast-food neighbourhood.

The association of deprivation and obesity has been consistently observed not only in England, but also in France and China. The study of Chung et al, (2019) demonstrates a strong positive correlation of abdominal obesity with deprivation. The analysis was based on the survey of a random sample of 2282 households in Hong Kong[20]. The large cohort study of French population (n=68698) showed similar findings, a strong positive deprivation-overweight relationships were found in areas of large cities and Paris suburban[21]. The literature was searched through PubMed, Google Scholar, Embase databases.

2. Methodology

STUDY DESIGN: case study research design

DATA COLLECTION:
The following data sources were used for data collection and interpretation: demographic data: Census 2011, Health Event data: NHS Hospital Episode Statistics, secondary data sets (Public Health Profiles data, Health Survey for England, ONS statistical data for mortality)[22,23,24,25].

DATA ANALYSIS:
Descriptive statistics and quantitative analysis of secondary routine numerical data collected by NHS Digital, National Health Survey, Public Health England- Public Health Profiles for local authorities are used.

The trends for hospital admissions with the diagnosis of T2D (ICD-10, E11) and mortality with the underlying cause of Diabetes LC-19 was analyzed through a comparative analysis of values, and visual presentation of the retrieved data.

The following statistical analyses were used to investigate the latest data for the prevalence, distribution of T2D and possible causal relationships with its determinants: the Pearson product-moment correlation coefficient (PPMCC) and the Spearman's rank correlation coefficient[26].

The correlation analyses were used to evaluate the strength, direction and monotonicity of relationships between the following variables: The Index of Multiple Deprivation Score, The Estimated Prevalence of Diabetes (diagnosed and undiagnosed); The Density of Fast Food Outlets, Percentage of (adults 18+) classified as overweight or obese, Diabetes: QOF Prevalence (17+Yrs) and Percentage of physically inactive adults (Table 1). The data for 2017/18 and 2021/22 years were analyzed (Table 2, 5). The test of Kolmogorov-Smirnoff will be applied to analyze normality of distribution. The analysis of outliers will be conducted through a data sorting and the Grabb's test for outliers[27].

Table 1. The definitions and sources of data collection for six health indicators.

Health Indicator	Definition	Source
Diabetes: QOF Prevalence (17+Yrs)	The percentage of patients aged 17 or over with diabetes mellitus, as recorded on practice disease registers	NHS Digital
The Percentage of (adults 18+) classified as overweight or obese	Percentage of adults aged 18 and over with BMI greater than or equal to 25kg/m²	Office for Health Improvement and Disparities
The Index of Multiple Deprivation Score	The English Indices of Deprivation use 37 separate indicators, organised across seven distinct domains of deprivation which can be combined, using appropriate weights, to calculate the Index of Multiple Deprivation(IMD)	Department of Communities and Local Government
Percentage of physically inactive adults	The number of respondents aged 19 and over, with valid responses to questions on physical activity, doing less than 30 moderate intensity equivalent (MIE) minutes physical activity per week in bouts of 10 minutes or more in the previous 28 days expressed as a percentage of the total number of respondents aged 19 and over	Office for Health Improvement and Disparities
The Estimated Prevalence of Diabetes (diagnosed and undiagnosed)	The diabetes prevalence model provides estimates of total (diagnosed and undiagnosed) diabetes prevalence for people aged 16 years and older in England	Health Surveys for England 2012, 2013 and 2014. Numbers of Patients registered at a GP practice - April 2015. Health Surveys for England 2012, 2103 and 2014. Numbers of Patients registered at a GP practice - April 2015. Hospital Episode Statistics (HES), 2012/13 - 2014/15
Density of Fast Food Outlets	Crude rate per 100,000 population: the number of fast food outlets is divided by the population of the area and multiplied by 100,000	Numerator: PontX, Poits of Interest Denominator, ONS mid-year estimates of population

Author used data from fingertips.phe.org.uk

Stratified random sampling is used for the analysis; all counties & UA of England (based on deprivation deciles defined in 2015/17 years) are divided into 10 strata representing ten deprivation deciles of England. By simple random sampling (every other) 80 counties & UA were randomly picked from these strata for the stratified analysis (Table 2,5). Additionally, the mean values of four indicators (2017/18) were counted for every deprivation decile (15 to 16 counties & UA in every decile) (Table 10). The choice of sampling is based on the Public Health Profile division of local authorities and their available indicators.[23]

3. Results

The Kolmogorov-Smirnoff's test confirmed that values for all health indicators included to the statistical analysis followed a normal distribution pattern ($p > 0,05$). The Grabb's test for outliers indicated an outlier within the data for the Density of Fast Food Outlets. The removal of several values which could be potential outliers had no influence on the results. The Pearson product-moment correlation coefficient (PPMCC) analysis based on 80 cases for 2017/18 year revealed a strong positive correlation between Diabetes: QOF Prevalence (17+ yrs) & Percentage of (adults 18 +) classified as overweight or obese (r– 0,6) (Figure 3, Table 2, 4);

Table 2. Health indicators for 2017/18 year

Stratum	County & UA	Estimated prevalence of diabetes (undiagnosed and diagnosed)	Diabetes: QOF Prevalence 17 +	Percentage of (adults18+) classified as overweight or obese	Density of Fast Food Outlets	IMD, 2015	Percentage of physically inactive adults
1 Most Deprived	Barking and Dagenham	9.2	8	62.5	97.8	34.6	33,6
	Blackburn with Darwen	9.9	8,3	65.9	128.1	34.2	30,5
	Hackney	9.1	5,8	49	110.2	35.3	18,8
	Knowsley	9.0	7,6	72.4	50.5	41.4	25,7
	Manchester	7.6	6,4	64.2	144.6	40.5	22,3
	Nottingham	7.8	5,8	64.5	115.8	36.9	22,6
	Sandwell	10.8	9,3	70.5	114.3	34.6	29,6
	Tower Hamlets	8.3	6,7	50.9	124.6	35.7	22,3
2 Second most deprived	Hartlepool	8.9	6,9	75.2	143.6	33.2	29,5
	Halton	8.5	8,2	73.3	68.1	31.9	24,5
	South Tyneside	9.2	7,4	70.2	102.9	30.6	27,1
	Sunderland	8.8	7,2	68.4	95.7	29.7	28
	Salford	7.8	6,4	66.7	106.6	33.0	23,9
	Newham	10.4	8,6	61.1	112.2	32.9	29,7
	Islington	7.3	5	47.4	133.5	32.5	15,2
	Haringey	9.1	6,2	51.8	95.3	31.0	20,9

Stratum	County & UA	Estimated prevalence of diabetes (undiagnosed and diagnosed)	Diabetes: QOF Prevalence 17 +	Percentage of (adults18+) classified as overweight or obese	Density of Fast Food Outlets	IMD, 2015	Percentage of physically inactive adults
3 Third more deprived	Rotherham	9.1	7,4	61.6	98.4	28.3	30,2
	Peterborough	8.7	6,9	67.9	82.4	27.7	24,7
	Doncaster	8.9	8	71.3	95.7	29.1	29,2
	Barnsley	8.9	7,4	68.7	97.5	29.6	25,7
	Coventry	8.6	6,7	64.9	83.6	28.1	29,5
	Torbay	10.4	7,4	60.5	120.3	28.8	20
	Southwark	8.8	6,2	51.3	112.1	29.5	16,8
	Westminster	8.2	4,3	45.8	198.9	27.7	20,1
4 Fourth more deprived	Plymouth	7.9	6,6	67.8	74.6	26.6	21
	Enfield	9.5	8	57.8	82.0	27.0	26,4
	Sefton	9.5	7,1	70.8	91.8	25.7	22,1
	Wakefield	8.8	7,4	67.7	119.5	26.9	28,5
	Southampton	7.1	5,7	64.5	106.4	26.9	21,7
	Gateshead	8.6	7	69.1	99.2	25.9	23,2
	Greenwich	8.3	6,7	58.7	86.0	25.5	19
	Brent	11.5	8,6	55.5	94.8	26.7	30,5
5 Fifth more deprived	Telford and Wrekin	8.4	7,4	65.5	75.0	24.9	24,3
	Kirklees	9.4	7,3	61.5	109.7	24.0	28,6
	Stockton-on-Tees	8.1	6,8	66	93.8	24.6	26,7
	Darlington	8.7	7,5	67.6	117.7	23.6	27,4
	Croydon	10.5	7	62.1	112.8	23.6	22,9
	Ealing	10.7	8,2	60.7	83.6	23.6	21,4
	Kensigton and Chelsey	8.5	4,4	48.8	64.0	23.4	20,9
	Camden	7.8	4,1	47	140.5	25.0	16,7
6 Fifth less deprived	Thurrok	7.9	6,7	67	84.5	21.6	26,7
	Medway	8.0	7,4	67.7	86.5	22.3	23,2
	Slough	10.2	9,2	66.2	77.5	22.9	34,2
	North Tyneside	8.5	7,3	63.1	103.6	21.3	29
	Northumberland	9.4	7,9	62.2	85.4	20.5	23,8
	Cumbria	9.4	7,4		95.2	21.3	
	Bury	8.7	7,4	63.9	118.4	21.8	23,3
	Bournemouth	7.8	5,3	60.9	109.2	21.8	17,5
	Herefordshire	9.5	6,9	63.7	55.0	19.7	23,2

Stratum	County & UA	Estimated prevalence of diabetes (undiagnosed and diagnosed)	Diabetes: QOF Prevalence 17 +	Percentage of (adults18+) classified as overweight or obese	Density of Fast Food Outlets	IMD, 2015	Percentage of physically inactive adults
7 Fourth less deprived	Warrington	7.9	6,7	64.7	76.1	19.3	24,6
	Derbyshire	8.7	7,4	64.9	83.5	18.5	21,8
	Kent	8.5	6,6	62.9	75.7	18.8	20
	Bedford	9.3	7,1	62	81.1	19.2	26,6
	East Sussex	9.5	6,7	60.9	74.5	18.8	22,6
	Hillingdon	8.8	7,4	61.8	87.5	18.1	27,5
	Wandsworth	7.1	4,3	54.3	98.0	18.3	16,6
8 Third less deprived	Shropshire	9.2	6,9	72.1	75.1	16.7	19,7
	Somerset	9.3	6,9	66.9	60.7	17.8	
	Swindon	7.7	7,6	62.1	61.6	17.9	18,9
	Trafford	8.3	6,6	57.4	114.4	15.4	20,8
	Havering	8.6	6,7	69.4	95.9	17.9	22,4
	Essex	8.5	6,6	62.6	69.5	17.2	21,8
	Devon	9.3	6,8	60.7	62.9	17.1	16,9
	Poole	8.6	6,4	60.9	97.3	15.2	17,5
9 Second least deprived	Bromley	8.3	5,6	51.9	79.4	15.2	21,8
	Leicestershire	8.4	6,8	60.9	65.6	12.5	23,3
	Sutton	7.9	6,7	57.2	90.3	14.6	27,2
	Cambridgeshire	7.6	5,7	58.7	59.4	13.4	20,3
	Gloucestershire	8.4	6,7	60.4	66.6	15.0	18,9
	York	6.9	5	56.5	98.8	12.2	13,8
	Harrow	10.9	9,7	52.3	81.7	14.3	27,8
	Dorset (Cty)	9.7	6,9	62.3	65.3	14.3	18,7
10 Least deprived	Central Bedfordshire	7.5	6,2	59.9	63.6	12.2	22,4
	Hampshire	8.1	6,3	62.9	62.5	11.9	19,1
	Bracknell Forest	6.8	5,7	60.2	36.4	10.5	15,1
	Wokingham	7.3	5	53.4	33.3	5.7	15,4
	Isles of Scilly	-	4,5		0.0	12.0	15
	Kingston upon Thames	6.7	5,1	51.5	80.0	11.1	19,4
	Windsdor and Maidenhead	8.0	5,1	58.1	68.5	8.9	18,2
	Richmond upon Thames	7.0	3,9	46.6	63.5	10.0	13

Author used data from fingertips.phe.org.uk

Table 3. Statistical characteristics of data for 2017/18 years

Variable N= 77	Means	Max	Min	Std. Deviation
Percentage of overweight and obese	61,58	75,2	45,80	6,86
IMD 2015	23,15	41,40	5,70	7,99
Diabetes: QOF Prevalence	6,76	9,70	3,90	1,18
Estimated Prevalence of D&U Diabetes	8,65	11,50	6,70	1,00
Physically inactive adults	23,04	34,20	13,00	4,73
Density of Fast Food Outlets	91,84	198,90	33,30	26,84

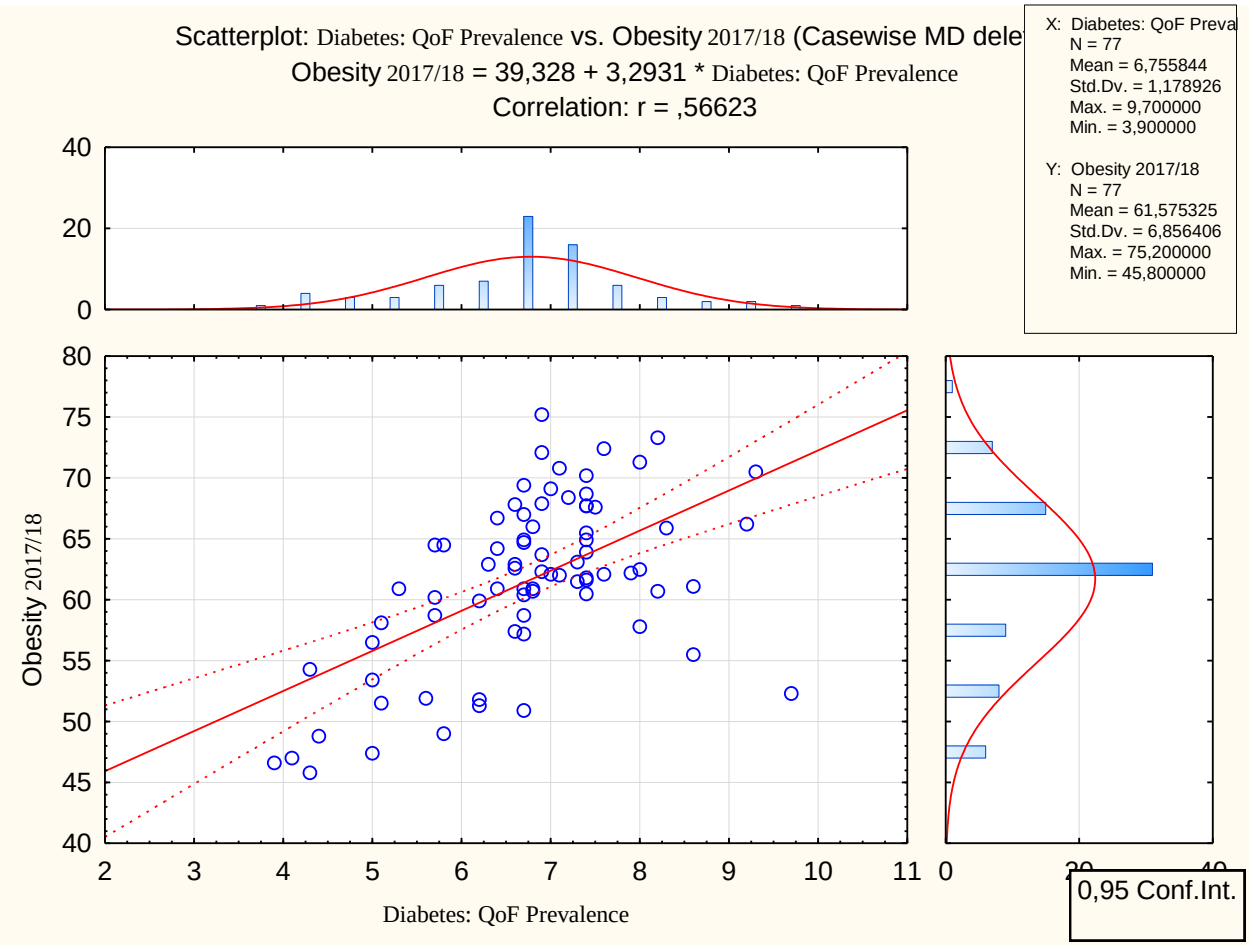


Figure 3. The scatterplot for Diabetes: QOF Prevalence (17 + yrs) vs Percentage of (adults 18 +) classified as overweight or obese (2017/18).

Density of Fast Food Outlets and Index of Multiple Deprivation score – (r-0,6) (Figure 4);

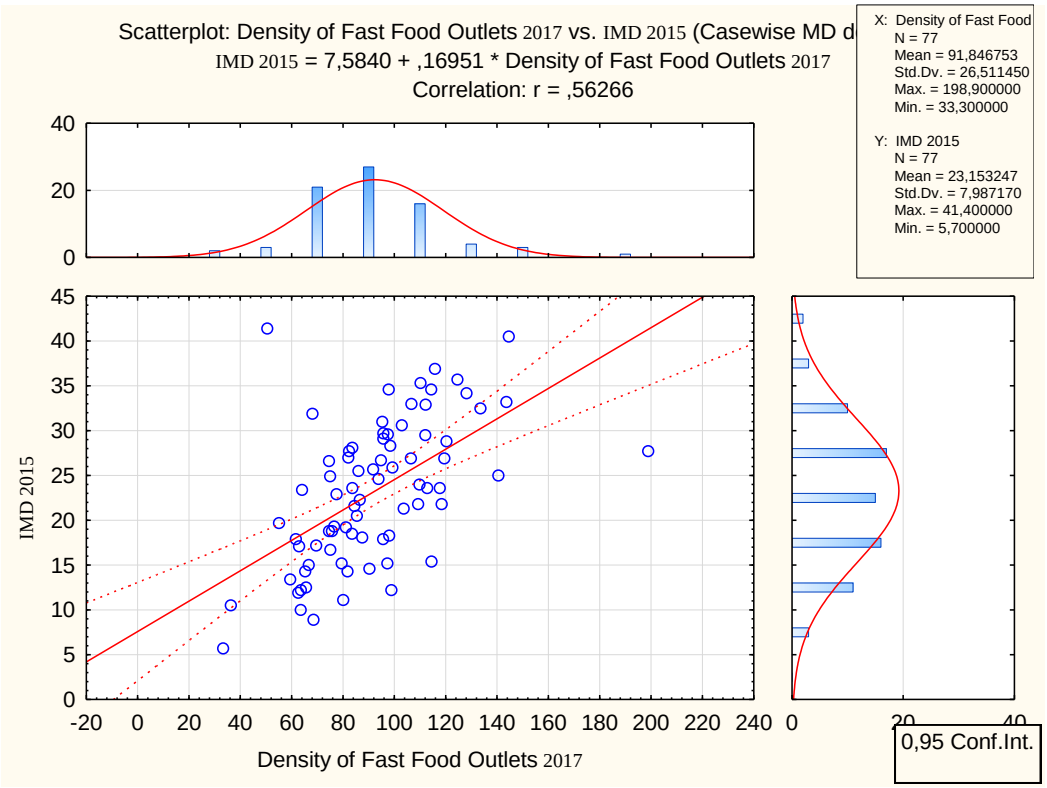


Figure 4. The scatterplot the Density of Fast Food Outlets vs Index of Multiple Deprivation Score, 2015 (2017/18).

Diabetes: QOF Prevalence (17+ yrs) and Percentage of physically inactive adults – (r- 0,7)(Table 4; Figure 5).

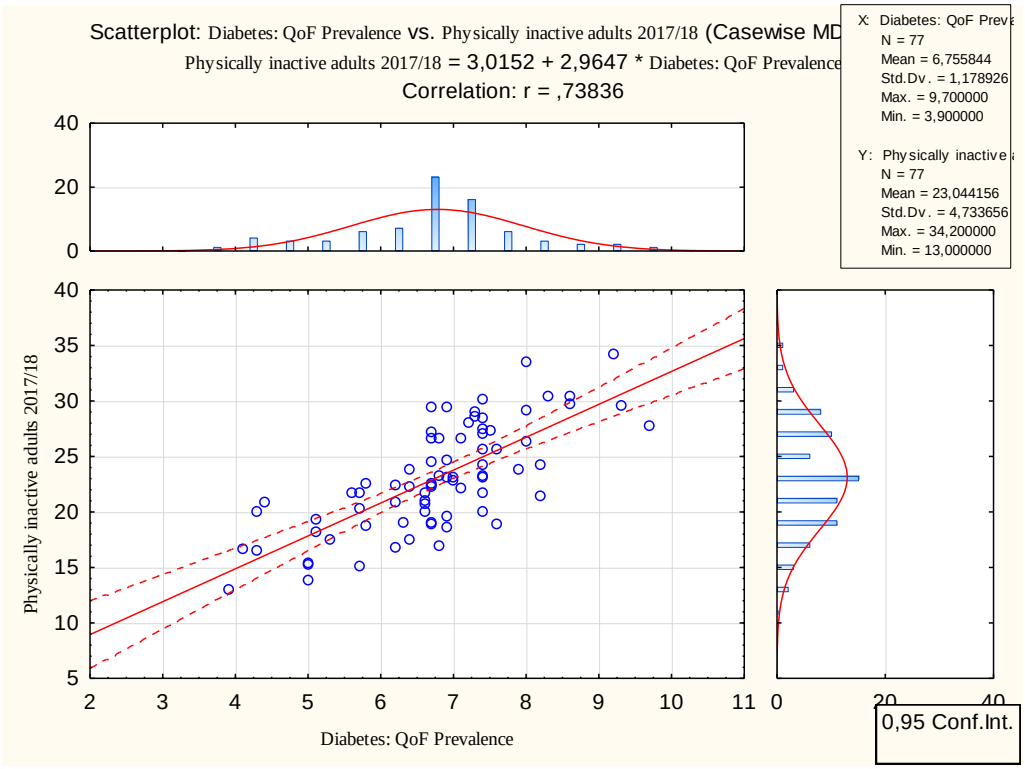


Figure 5. The scatterplot for Diabetes: QOF Prevalence (17 + yrs) vs Percentage of physically inactive adults (2017/18).

The moderate positive correlations were observed between Percentage of (adults 18 +) classified as overweight or obese and Percentage of physically inactive adults (r- 0,5); Percentage of physically inactive adults and Index of Multiple Deprivation score (r- 0,4) (Table 4).

Table 4. The results of Pearson's Correlation Analysis for health indicators, 2017/18

Variable N=76	Pearson's R	P-value
Diabetes QOF Prevalence / Percentage of overweight and obese	0,566	0,000
Diabetes QOF Prevalence / IMD 2015	0,308	0,006
Diabetes QOF Prevalence / Physically inactive adults	0,738	0,000
Density of Fast -Food Outlets/IMD, 2015	0,563	0,000
IMD 2015/Physically inactive adults	0,443	0,000
Percentage of overweight and obese / Physically inactive adults	0,500	0,000
Percentage of overweight and obese /IMD 2015	0,267	0,019
Estimated Prevalence of D&U Diabetes/ IMD 2015	0,305	0,007
Estimated Prevalence of D&U Diabetes/ Physically inactive adults	0, 543	0,000

The weak positive linear relationships were detected between the Diabetes: QOF Prevalence (17+ yrs) vs Index of Multiple Deprivation Score, 2015 (Figure 6);

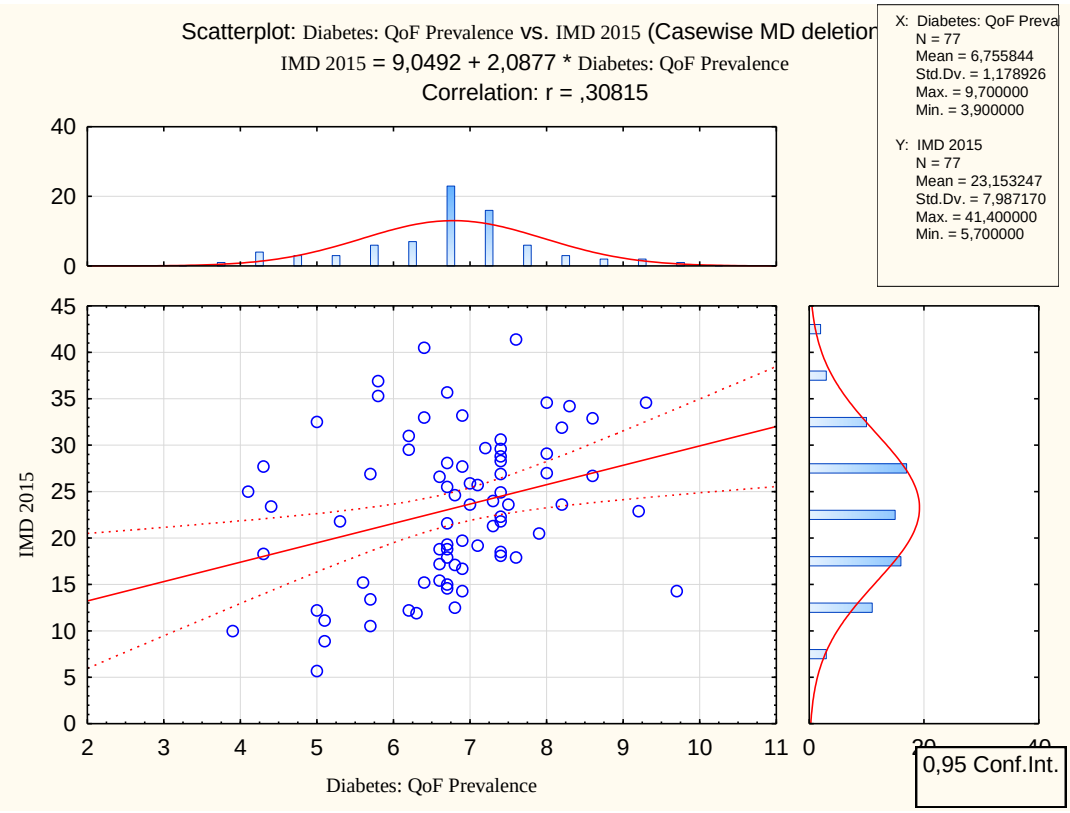


Figure 6. The scatterplot for Diabetes: QOF Prevalence (17 + yrs) vs Index of Multiple Deprivation Score, 2015 (2017/18).

Percentage of (adults 18 +) classified as overweight or obese and Index of Multiple Deprivation score (r- 0,3) (Table 4).

The Pearson's correlation analysis of data for 2021/22 demonstrated the same positive associations indicated in the previous analysis for 2017/18 and confirmed the statistical findings (Table 7).

Table 5. Health indicators for 2021/22 year

Stratum	County & UA	Diabetes: QOF Prevalence 17+ yrs	Percentage of (adults18+) classified as overweight or obese	Percentage of physically inactive adults	Density of Fast Food Outlets	IMD, 2019
1 Most Deprived	Barking and Dagenham	8,9	70,5	35	97.8	32,8
	Blackburn with Darwen	9	68,4	37,6	128.1	36
	Hackney	6,1	46,9	18	110.2	32,5
	Knowsley	8,2	74,6	25,2	50.5	43
	Manchester	6,6	59,9	26,3	144.6	40
	Nottingham	6,3	65,8	23,3	115.8	34,9
	Sandwell	10,1	69,7	31	114.3	34,9
	Tower Hamlets	6,7	47,8	20,5	124.6	27,9
2 Second most deprived	Hartlepool	7,9	76,2	28,6	143.6	35
	Halton	8,4	71,2	23,7	68.1	32,3
	South Tyneside	8,1	76,3	28,1	102.9	31,5
	Sunderland	8,2	73,9	24,5	95.7	30,6
	Salford	6,5	68,8	26,7	106.6	34,2
	Newham	8,7	47,3	25,7	112.2	29,6
	Islington	4,5	51	17,1	133.5	27,5
	Haringey	6,4	49	27,9	95.3	28
3 Third more deprived	Rotherham	8,2	71,9	24,4	98.4	29,6
	Peterborough	7,7	66,8	30,2	82.4	27,8
	Doncaster	8,5	73,3	28,5	95.7	30,3
	Barnsley	8,1	70,9	26	97.5	29,9
	Coventry	7,1	65,3	28,1	83.6	25,6
	Torbay	7,8	68,9	20,5	120.3	28,1
	Southwark	6,3	44,2	22,3	112.1	25,8
	Westminster	4	49,7	20,9	198.9	20,3
4 Fourth more deprived	Plymouth	7,4	68,5	23,6	74.6	26,6
	Enfield	8,4	63,8	28,7	82.0	25,8
	Sefton	7,5	71,2	24,5	91.8	27
	Wakefield	8,2	76,4	27,7	119.5	27,3
	Southampton	6,2	67	22,6	106.4	26,9
	Gateshead	7,9	68,4	27,4	99.2	28,2
	Greenwich	6,9	60,4	26,3	86.0	24,5
	Brent	8,6	58,8	27,7	94.8	25,6

Stratum	County & UA	Diabetes: QOF Prevalence 17+ yrs	Percentage of (adults18+) classified as overweight or obese	Percentage of physically inactive adults	Density of Fast Food Outlets	IMD, 2019
5 Fifth more deprived	Telford and Wrekin	8	71,4	26,8	75.0	25
	Kirklees	8,4	60,5	21,6	109.7	25,2
	Stockton-on-Tees	7,4	70,1	25,1	93.8	25,8
	Darlington	8,2	70,1	24,2	117.7	25,7
	Croydon	7,5	62,6	25	112.8	22,5
	Ealing	9	57,6	21,3	83.6	22,7
	Kensigton and Chelsey	4,1	45,5	23,4	64.0	21,5
	Camden	3,9	50,1	17,8	140.5	20,1
6 Fifth less deprived	Thurrok	7,4	69,7	25,5	84.5	20,9
	Medway	7,9	67,2	20,9	86.5	23,9
	Slough	10,2	66	26,8	77.5	23
	North Tyneside	8	70,7	33,7	103.6	22,3
	Northumberland	8,5	63,4	22,6	85.4	22,1
	Cumbria	7,8	65	21,2	95.2	
	Bury	7,5	64,9	22	118.4	23,7
	Bournemouth				109.2	18,2
7 Fourth less deprived	Herefordshire	7,2	64,7	20,1	55.0	18,9
	Warrington	7	66,7	21,1	76.1	18,9
	Derbyshire	8	70,6	20,6	83.5	18,4
	Kent	7,2	65,8	20,6	75.7	19,5
	Bedford	7,6	61,9	22,6	81.1	18,9
	East Sussex	7,3	62,7	18,7	74.5	19,8
	Hillingdon	8,1	62,3	26,3	87.5	18,2
	Wandsworth	4,6	50,8	15,9	98.0	16,6
8 Third less deprived	Shropshire	7,1	67,4	19,9	75.1	17,2
	Somerset	7,6	66,3	19,7	60.7	18,6
	Swindon	8,2	69,1	23,4	61.6	18,6
	Trafford	6,5	61,7	20,1	114.4	16,1
	Havering	7,6	60,9	27,9	95.9	16,8
	Essex	7,2	65,3	21,6	69.5	17
	Devon	7,2	60,5	16,8	62.9	16,6
	Poole				97.3	18,2
9 Second least deprived	Bromley	6,2	60,8	18,9	79.4	14,2
	Leicestershire	7,2	64,1	21,4	65.6	12,3
	Sutton	7,2	57,8	26,9	90.3	14
	Cambridgeshire	6	60	19,3	59.4	13,9
	Gloucestershire	7	62,4	18,8	66.6	14,9
	York	5,1	59,5	15,4	98.8	11,7
	Harrow	10,2	55,2	28	81.7	15
	Dorset (Cty)				65.3	15,7
10 Least deprived	Central Bedfordshire	6,7	68,5	21,8	63.6	12,2
	Hampshire	7	64,2	17,7	62.5	12,7

Stratum	County & UA	Diabetes: QOF Prevalence 17+ yrs	Percentage of (adults18+) classified as overweight or obese	Percentage of physically inactive adults	Density of Fast Food Outlets	IMD, 2019
	Bracknell Forest	6,2	64,6	19,1	36.4	10,2
	Wokingham	5,6	61,4	17,4	33.3	5,8
	Isles of Scilly	4,7	53,6	17,5	0.0	12
	Kingston upon Thames	5,5	57,2	15	80.0	11,4
	Windsdor and Maidenhead	5,7	55,7	14,9	68.5	8,4
	Richmond upon Thames	4,2	56,4	18,3	63.5	9,4

Author used data from fingertips.phe.org.uk

Table 6. Statistical characteristics of data for 2021/22 years

Variable N= 76	Means	Max	Min	Std. Deviation
Percentage of overweight and obese	63,30	76,40	44,20	7,83
IMD 2019	22,80	43,00	5,80	7,85
Diabetes: QOF Prevalence	7,21			1,38
Physically inactive adults	23,30	37,60	14,90	4,67
Density of Fast Food Outlets	91,84	198,90	33,30	26,84

Table 7. The results of Pearson's Correlation Analysis for health indicators, 2021/22

Variable N=76	Pearson's R	P-value
Diabetes QOF Prevalence /Percentage of overweight and obese	0,551	0,000
Diabetes QOF Prevalence / IMD 2019	0,385	0,001
Diabetes QOF Prevalence / Physically inactive adults	0,625	0,000
Density of Fast -Food Outlets/IMD 2019	0,489	0,000
IMD 2019/Physically inactive adults	0,598	0,000
Percentage of overweight and obese / Physically inactive adults	0,408	0,000
Percentage of overweight and obese /IMD 2019	0,307	0,011

The results of Spearman's correlation analysis for both 2017/18 and 2021/22 years almost replicated these findings and revealed the significant monotonic association between the indicators for obesity, diabetes, deprivation score and physically inactive adults; deprivation score and density of fast food outlets (Table 8, 9).

Table 8. The results of Spearman's correlation analysis for health indicators, 2017/18.

Variable	Spearman's R	P-value	Valid - N
Diabetes QOF Prevalence / Percentage of overweight or obese	0,524	0,000	78
Diabetes QOF Prevalence / IMD 2015	0,343	0,001	
Diabetes QOF Prevalence / Physically inactive adults	0,742	0,000	78
Density of Fast -Food Outlets/IMD 2015	0,612	0,000	79
IMD 2015/Physically inactive adults	0,463	0,000	78
Percentage of overweight or obese/ Physically inactive adults	0,531	0,000	77
Percentage of overweight or obese /IMD 2015	0,324	0,003	78
Estimated Prevalence of D&U Diabetes/IMD 2015	0,295	0,008	79
Estimated Prevalence of D&U Diabetes/ Percentage of overweight or obese	0,252	0,025	78

The associations showed a high statistical significance with the p-values of 0,000 in almost all cases. The strongest associations were indicated between Diabetes: QOF Prevalence (17 +yrs) and Percentage of (adults 18+) classified as overweight or obese(r- 0,5); Index of Multiple Deprivation Score, 2015/2019 and Percentage of physically inactive adults (r-0,5; r-0,6); Density of Fast Food Outlets and Index of Multiple Deprivation Score, 2015/2019 (r -0,6) (Table 8,9).

Table 9. The results of Spearman's correlation analysis for health indicators, 2021/22.

Variable	Spearman's R	P-value	Valid - N
Diabetes QOF Prevalence / Percentage of overweight or obese	0,546	0,000	77
Diabetes QOF Prevalence / IMD 2019	0,445	0,000	76
Diabetes QOF Prevalence / Physically inactive adults	0,650	0,000	77
Density of Fast -Food Outlets/IMD 2019	0,573	0,000	79
IMD 2019/Physically inactive adults	0,610	0,000	76
Percentage of overweight or obese/ Physically inactive adults	0,460	0,000	77
Percentage of overweight or obese /IMD 2019	0,419	0,000	76

The results of both Spearman's and Pearson's correlation analyses for 2021/22 year revealed an increase in the prevalence of diabetes and the deprivation score-(r- 0,4)(Table 7, 9; Figure 7).

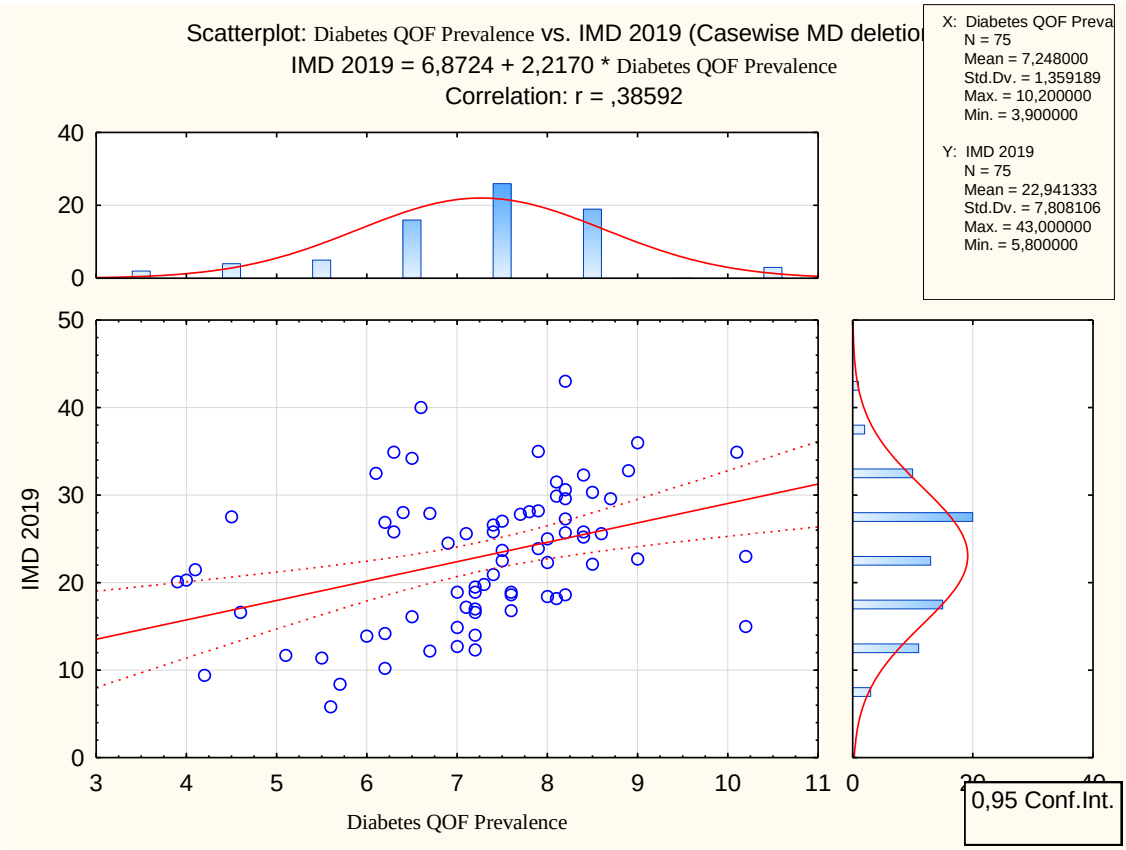


Figure 7. The scatterplot for Diabetes: QOF Prevalence (17 + yrs) vs Index of Multiple Deprivation Score, 2019 (2021/22).

The Pearson's correlation analysis of mean values (10 cases representing the mean values of six health indicators in ten deprivation deciles), reflected stronger linear relationships (r – 0,7 to 0,9) between indicators of diabetes, deprivation, low physical activity and obesity (Table 10, 11).

Table 10. The mean values of six indicators in 10 England's deprivation deciles 2017/18.

Deprivation decile	Estimated prevalence of Diabetes (diagnosed & undiagnosed) (mean value) %	Percentage of (adults 18+) classified as overweight or obese (mean value) %	Density of Fast Food Outlets (mean value) N	IMD,2015 (mean value) N	Percentage of physically inactive adults (mean value) %	Diabetes:QOF Prevalence (17 + yrs) (mean value) %
Most deprived decile	9,1	65,2	114,4	38,1	25,7	7,2
Second most deprived decile	9,2	63,8	109,2	32,8	25	7,0

Deprivation decile	Estimated prevalence of Diabetes (diagnosed & undiagnosed) (mean value) %	Percentage of (adults 18+) classified as overweight or obese (mean value) %	Density of Fast Food Outlets (mean value) N	IMD,2015 (mean value) N	Percentage of physically inactive adults (mean value) %	Diabetes:QOF Prevalence (17 + yrs) (mean value) %
Third more deprived decile	8,9	63,2	107,6	28,2	25	6,8
Fourth more deprived decile	8,7	63,2	103,3	25,6	24,1	7,1
Fifth more deprived decile	8,3	61,0	101,1	23,7	24	6,6
Fifth less deprived decile	8,4	61,0	90,7	20,8	25,4	7,1
Fourth less deprived decile	8,5	63,4	79,4	18,9	23	6,6
Third less deprived decile	8,7	63,8	72,5	16,1	17,3	6,0
Second least deprived decile	8,5	60,0	76,2	14,2	21,5	6,6
Least deprived decile	7,6	58,3	61,4	11,7	17,2	5,2

Author used data from fingertips.phe.org.uk

Table 11. The results of Pearson's Correlation Analysis for health indicators, 2017/18

Variable N=10	Pearson's R	P-value
Diabetes QOF Prevalence /Density of fast food outlets	0,828	0,003
Diabetes QOF Prevalence / IMD 2015	0,740	0,015
Diabetes QOF Prevalence / Physically inactive adults	0,920	0,000
Density of Fast -Food Outlets/IMD 2015	0,946	0,000
Density of Fast -Food Outlets/ Estimated prevalence of diabetes (diagnosed & undiagnosed)	0,755	0,012
IMD 2015/Physically inactive adults	0,779	0,008
Estimated prevalence of diabetes (diagnosed & undiagnosed)/ Percentage of overweight and obese	0,878	0,001
Percentage of overweight and obese / Density of Fast Food Outlets	0,636	0,048
Percentage of overweight and obese /IMD, 2015	0,738	0,015

Also, unlike the statistical analysis of 80 cases, the analysis of mean values established a strong linear relationship between the following indicators: the Diabetes: QOF Prevalence (17 +yrs), Estimated prevalence of diabetes (diagnosed & undiagnosed) / Density of Fast Food outlets (r – 0,8, p- value for both lower than 0,05) (Table 11; Figure 8).

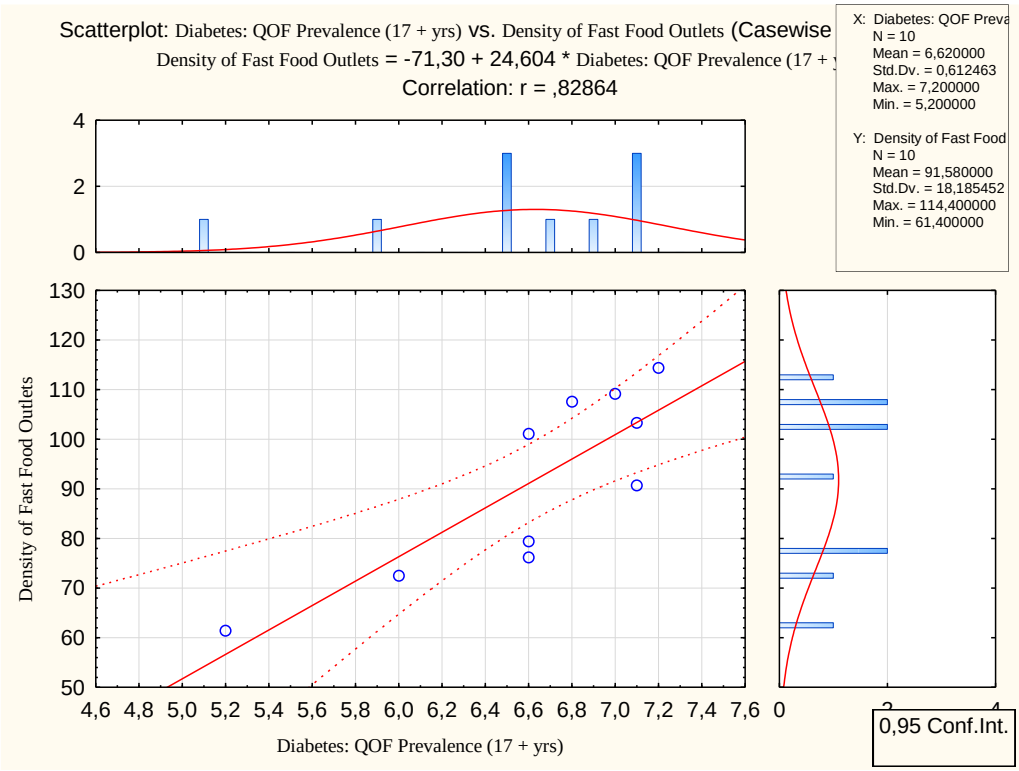


Figure 8. The scatterplot for Diabetes: QOF Prevalence (17 + yrs) vs Density of Fast Food Outlets (mean values), 2017/18.

Percentage of (adults 18 +) classified as overweight or obese / Density of Fast Food Outlets (r- 0,6; p- 0,048) (Table 11; Figure 9).

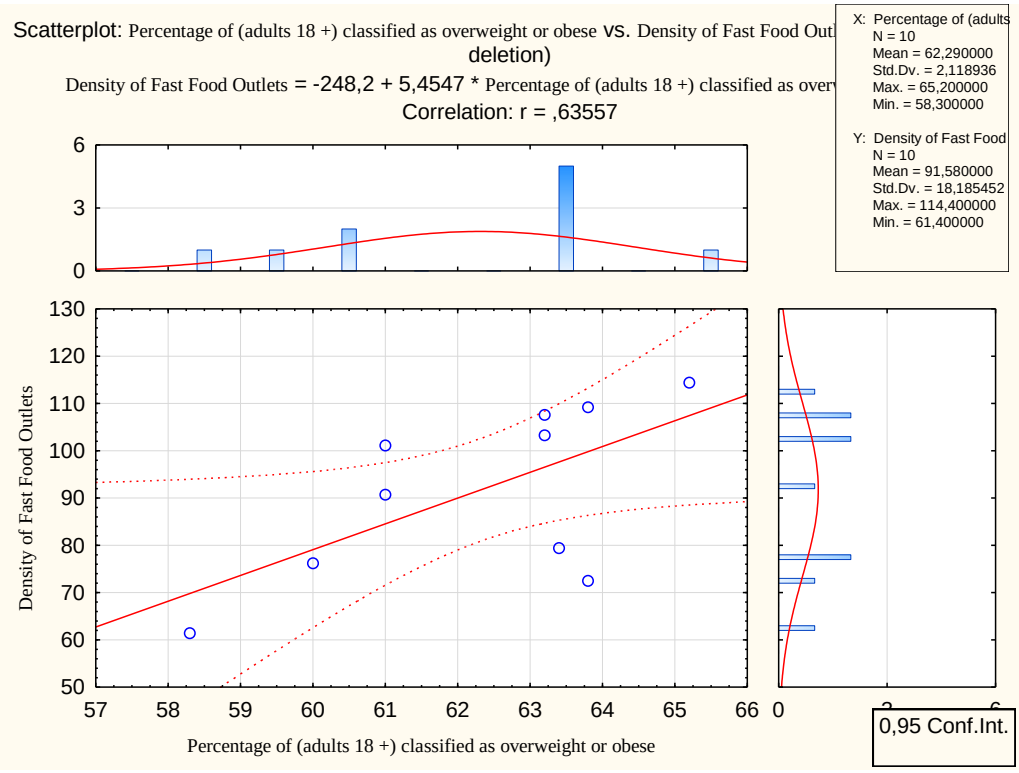


Figure 9. The scatterplot for the Percentage of (adults 18+) classified as overweight or obese vs Density of Fast Food Outlets (mean values), 2017/18.

Overall, all health indicators except the Estimated prevalence of diabetes (diagnosed & undiagnosed) and Density of Fast Food Outlets (latest update is 2017) revealed a stable increase within the 2017- 2022 time period.

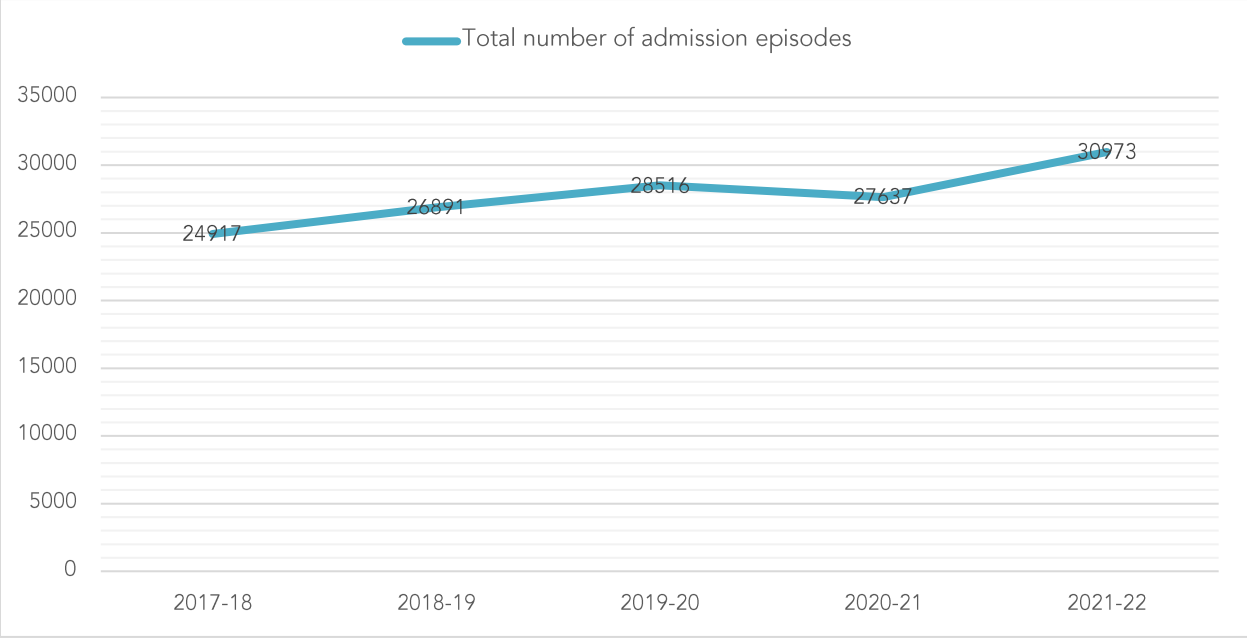
The comparative analysis of total hospital admissions with the diagnosis of T2D demonstrated that the number of patients required hospitalization increased by 24,3% from 2017 to 2022 (Figure 10).

Table 12. Hospital episodes statistics for England. Hospital admissions with a primary diagnosis of Diabetes Type 2 (ICD-10 - E11 code), broken down by 10 year age bands for the financial years 2017- 2022.

Age band	Hospital Admissions				
	2017-18	2018-19	2019-20	2020-21	2021-22
20-29	473	518	496	556	621
30-39	1350	1434	1506	1699	1866
40-49	3937	4074	4140	4589	4896
50-59	8289	8897	10112	9768	10812
60-69	8767	10131	11104	10956	12292
70-79	9752	10676	11329	11047	12497
80-89	8054	8980	9566	8679	9905
90+	1500	1609	1858	1660	1817
Total number of admissions	24917	26891	28516	27637	30973

Author used data from NHS Digital(digital.nhs.uk)

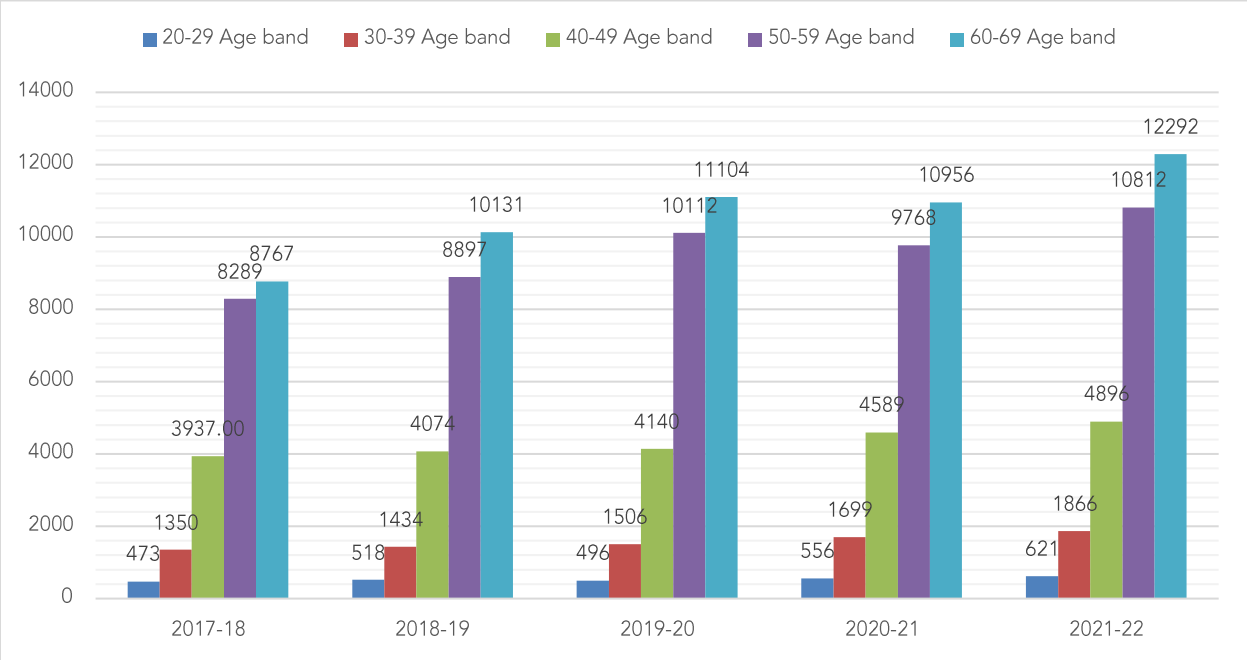
Figure 10. The total number of hospital admissions with a primary diagnosis Diabetes Type 2 (E11), 2017-22.



Author used data from National Health Service Digital (digital.nhs.uk).

The number of people admitted to hospitals grew in all age bands including the youngest 20-29 and 30-39 groups. The number of admissions increased with age (Table 12, Figure 11).

Figure 11. The number of hospital admissions with a primary diagnosis Diabetes Type 2 (E11) for five different age bands, 2017- 2022.



Author used data from National Health Service Digital (digital.nhs.uk)

With regards to the mortality for the underlying cause -Diabetes LC 19, the number of deaths grew from 2017 to 2021 by 21,4% reflecting an increasing trend (Table 13)[24].

Table 13. Mortality Statistics for all ages and both genders with underlying cause of Diabetes LC19

Region	2017	2019	2020	2021
North East	295	298	342	357
North West	630	691	828	784
Yorkshire and Humber	594	613	680	711
East Midlands	561	590	749	665
West Midlands	745	763	931	897
East	663	730	880	
London	684	768	804	772
South East	817	927	980	1048
South West	684	727	802	814
Column Total	**5673**	**6107**	**7100**	**6889**

Author used data from Office for National Statistics (nomisweb.co.uk)

4. Discussion

This analysis showed that more deprived areas of England contain the highest numbers of fast food outlets and have a higher prevalence of diabetes, overweight, obese and physically inactive adults. The positive relationships are identified between diabetes and low physical activity, obesity and deprivation. The strong association revealed between the density of fast food outlets and the deprivation score, can be interpreted as an indirect additional, contributing factor for T2D. This assumption draws on the findings of the statistical analysis that showed that all the main prerequisites of T2D, such as obesity and low physical activity are strongly associated with deprivation. Moreover, the direct strong correlation of diabetes, obesity and density of fast food outlets was detected by the Pearson's correlation analysis of mean values (Figure 8,9).

The associations revealed by statistical analyses remained the same in both 2017/18 and 2021/22 years. Regarding the Diabetes: QOF prevalence (17+ yrs), the mean value for this variable increased from 6,76 in 2017/18 to 7,21 in 2021/22 (Table 3,6). Starting from 2017, the trend for Diabetes: QOF prevalence (17+ yrs) is increasing across all the observed counties & UA, including least deprived deciles, except Islington, Westminster, Kensington & Chelsey and Camden, where numbers show a slight decrease (Table 2,5). The Pearson's analysis of 2017/18 and 2021/22 data showed the strong direct correlation of this indicator with the two indicators representing physical inactivity and obesity with r- 0,7 and 0,6, respectively. The Spearman's analysis demonstrated the similar findings with the moderate association between diabetes prevalence and obesity with r-0,5; the same strong direct relationships were defined between diabetes prevalence and percentage of physically inactive adults (r-0,7). Both statistical analyses established weak positive associations of diabetes prevalence indicator with index of multiple deprivation score (r- 0,3 in 2017/18, and 0,4 in 2021/22).

The analysis of indicator Estimated prevalence of diabetes (diagnosed & undiagnosed) produced similar results - the moderate strength of association with percentage of physically inactive adults (Pearson's r- 0,5) and weak positive correlation with the deprivation score (Pearson's r- 0,3).

The trend for the prevalence of overweight and obese follows a similar pattern- the three most deprived areas, except Haringay, Islington and some counties from the two least deprived deciles, reflect the highest increase. The mean value for this variable increased from 61,58 in 2017/18 to 63,30 in 2021/22 (Table 3,6). The analysis revealed the moderate strength of associations between the obesity indicator and percentage of physically inactive adults (Pearson's r- 0,4 in 2017/18 and 0,5 in 2021/22) (Table 4,7). Similar to the diabetes prevalence indicator, a weak positive relationship was detected between the prevalence of obesity and index of multiple deprivation score for the both divisions of 2015 and 2019 years (Pearson's r- 0,3 in 2017/18, 2021/22; Spearman's r - 0,3 in 2017/18 and r- 0,4 in 2021/22).

The trend for the percentage of physically inactive adults demonstrates a slight increase in the overall number for England – (2017/18

- 22,2%; 2021/22 – 22,3%); similarly, the highest prevalence and increase is observed in the three most deprived deciles.

With regards to the variable Index of Multiple Deprivation Score, the strong to moderate positive relationships were detected between 1) the deprivation score and density of fast food outlets (Pearson's r- 0,6, Spearman's r – 0,5 in 2017/18); (Pearson's r- 0,5, Spearman's r- 0,6 in 2021/22), 2) the deprivation score and the percentage of physically inactive adults (Pearson's r- 0,4, Spearman's r – 0,5 in 2017/18); (Pearson's r- 0,6, Spearman's r- 0,6 in 2021/22). The strength of association increased over a five year period.

The analysis of diabetes morbidity was conducted using the statistical records of admitted patient care activity in English NHS hospitals and English NHS-commissioned activity in the independent sector. The data were retrieved from the Hospital Episodes Statistics (HES) data warehouse. This analysis does not include finished consultant episodes, but only finished admission episodes[25].Concerning a total number of hospital admissions with a primary diagnosis of T2D, the number of admissions increased over a 5-year period in all studied age groups by 24,3%. The highest increase was detected in the following age groups: 20-29 (31,28%), 30-39 (38,22%), 50-59 (30,43%), 60-69 (40,2%) (Table 12, Figure 11). This positive trend is observed even in the youngest age group (20-29) which is a worrying fact because adverse diabetes and cardiovascular complications are more common among people who develop diabetes at an early age[28].

The analysis of mortality from 2017 to 2021, displayed the increase by 21,4% in the number of deaths with the underlying cause of Diabetes LC-19 across all England regions with the highest number in South- East region (increased by 28,8%, a total number – 1048) and West Midlands region (increased by 20%, a total number -897) regions. The number of deaths in England was the highest in 2020 year (a total number – 7100) (Table 13).

STRENGTHS

The stratified random sampling allows obtaining a sample that best represents the whole population being researched. Also, randomization increases generalizability and validity of the results and substantially improves the quality of evidence-based studies by minimizing a selection bias[29].

Routine data sources include not only register-based data, but also National Health Surveys which enhance the quality of information[30].Health surveys used in this study provide additional information about the prevalence of diabetes adjusted by age, sex, ethnic group and deprivation. Health surveys have relatively accurate data and are helpful in monitoring trends in the nation's health, estimating the prevalence of risk factors and conditions associated with them[27,31]. A large sample size was selected for this analysis- this increases a statistical power. Also, the data has been collected independently of the study and therefore various types of bias are reduced; adjustments for confounders available for the whole population have much higher validity than self-reported data[30,32,33].

LIMITATIONS

This study has several limitations: first, routine epidemiological data has a lower quality; routine morbidity data sources are not

complete because only those who approach health services are routinely recorded, meaning a large proportion of the population are underreported or undetected in the disease[34,35]. Secondly, public health profiles provide only data for prevalence not for incidence, and in this case only an approximate number for the incidence proportion was counted based on the projection for population data made by PHE based on Census 2011 and the annual rounded number of new cases of T2D. Therefore, the actual number of residents and incidence rate may differ[11,24].

Another limitation of this analysis is that separate indicators for prevalence and incidence of T2D within 18+ adult group were unavailable for the sequence of surveyed years and a general indicator for both types of diabetes was chosen. The choice is justified by the fact that T2D accounts for more than 90% of diabetes cases[1].

The data for Hospital Episode Statistics (HES) cannot be used for counting the people who were admitted to hospital within a given time period, because HES counts the number of episodes of care for admitted patients rather than the number of patients. Therefore, the data used reflect only an overall increase in admissions for T2D over a specific time period[25].

The indicator Estimated prevalence of diabetes (diagnosed & undiagnosed) was not available for 2021/22 years (latest update 2017), so the Diabetes: QOF Prevalence (17+yrs) indicator was used for the years 2021/22, pairing all six indicators with 100% accuracy was not possible; the data for the Density of Fast Food Outlets was not updated in 2021/22, so the correlation analyses used the update for 2017 year.

Concerning mortality data, statistics based on death certificates usually underestimate the incidence of deaths attributable to diabetes. The reason is that each death is assigned to a single underlying cause of death, and deaths are seldom assigned to diabetes if another disease appears on the certificate, even if the diabetes contributed to this other disease. Mortality rates are two to three times higher in diabetics, but only 10-20% of the death certificates of diabetics assign diabetes as the underlying cause of death[24,36]. Additionally, the indicator for diabetes mortality is a linked code for all types of diabetes.

In terms of the prevalence of T2D, the increase in prevalence occurred not only because of new cases accrual, but also due to the aging population i.e. the longer duration of the disease[1].

5. Conclusion

In conclusion, drawing on the results of the statistical analysis examining diabetes, obesity and deprivation related health indicators of 80 randomly picked England counties & UA, the main contributing risk factors for the increasing trend of T2D is obesity, low physical activity and deprivation. The indirect risk factor of T2D is the density of fast food outlets in more deprived areas of England. The analysis showed that the availability and abundance of fast food outlets are closely associated with both obesity and diabetes; targeting policies at the reduction of fat, sugar and overall calorific capacity in these products are highly recommended.

Concerning hospital admissions with the diagnosis of T2D and diabetes mortality statistics, the growing numbers of admissions and deaths reflected a similar upward tendency as prevalence of T2D in England.

RECOMMENDATIONS:

The current study's findings are quite consistent with the results of previous studies and the suggestion is that prevention measures should be focused mostly on deprived population groups. In addition to this, drawing on the fact that the number of fast- food points increase with the deprivation index, the level of consumption is high, particularly, in deprived groups. The low price, good taste and easy access increases popularity of such products.

The attempts to reduce the consumption through taxation of fast-food industries showed little effect on obesity. According to the study of Cotti, (2013), the taxation of beverages and fast food products which contribute to obesity will have little effect on reduction of BMI among adults. The observation of changes in fast food prices did not reveal a statistically significant change in BMI and obesity in United States. The reason is a low price of fast food which requires a large tax to be imposed to detect changes in behaviour. Another obstacle to combating obesity through taxes is unavailability or limited availability of healthy substitutes in many areas[37].

Another option to minimize a risk fast food consumption might be a change of their caloric capacity through the substitution of sugar with sweeteners like cyclamate saccharin, stevia and other intense sweeteners with high permitted levels of use[38].

Sweeteners provide an alternative to added sugars and may limit caloric intake. Low-calorie sweeteners (LCS) have already been suggested as sugar substitutes for a diabetic population[39]. The suggestion is to scale up the use of sweeteners among wider non-diabetic population as a preventive measure for obesity and T2D. Sugar substitutes is suggested for a use in ice-creams, deserts and beverages served in popular fast-food restaurants. A maximum effect would be the implementation of these changes in large manufacturers like McDonalds, KFC, Coca Cola company, leaving sugar only in energizers. The sugar may not be excluded fully but reduced and substituted by a sweetener for example by half. The reduction by half will lower the overall caloric intake from 140 calories (12 fl oz volume) to 70 calories. Today, Coca Cola company has introduced sugar -free options, but sugar-contained options are still prevalent[40]. This measure maybe coupled with the reduction of dish sizes on the menu.

The projections for the current issue have already been made by Public Health England stating that incidence of T2D will increase, the same projections were made for its main determinant - obesity[1 6]. This epidemic may be curbed if radical changes will be implemented on a national level primarily in fast-food industries and soft drinks producing companies

Conflict of Interest Statement:

None

Compliance with Ethics Guidelines

This article is based on secondary data and does not contain any studies with human participants or animals performed by the author.

Acknowledgement Statement:

None

Funding Statement:

No funding was provided for this articles and author has nothing to declare

References:

1. Public Health England. Health Matters: preventing Type 2 Diabetes. https://www.gov.uk/government/publications/health-matters-preventing type-2-diabetes/health-matters-preventing-type-2-diabetes#scale-of-the-problem Published 2018. Accessed August 1, 2023.

2. World Health Organization. Diabetes. https://who.int/healthtopics/diabetes#tab=tab_1 Published 2023. Accessed July 31, 2023.

3. Saeedi P, Petersohn I, Salpea P. et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract.* 2019; 157:107843. https://pubmed.ncbi.nlm.nih.gov/31518657/ Accessed August 15, 2023.

4. National Health Service Digital. National Diabetes Audit (NDA) 2019-2020 quarterly report for England, Clinical Commissioning Groups and GP practices. https://digital.nhs.uk/search?query=national+diabetes+audit+quarterly+report Published 2020. Accessed August 6, 2023.

5. Heald A, Stedman M, Robinson A. Mortality Rate Associated with Diabetes: Outcomes From a General Practice Level Analysis in England Using the Royal College of General Practitioners (RCGP) Database Indicate Stability Over a 15 Year Period. *Diabetes Ther.* 2022; 13(12): 1-12. DOI: 10.1007/s13300-022-01215-1 Accessed August 17, 2023

6. Public Health England. Estimates by CCG tool for the impact of obesity on diabetes. https://www.gov.uk/government/publications/diabetes-prevalence-estimates-for-local-populations Published 2016. Accessed July 24, 2023.

7. National Health Service Digital. National Diabetes Audit Report 1- Findings and recommendations2018. https://digital.nhs.uk/data-and information/publications/statistical/national-diabetes-audit/national-diabetes-audit-report-1-findings-and-recommendations-2016-17 Published 2019. Accessed August 9, 2023.

8. Public Health England. Health Matters: obesity and the food environment. https://www.gov.uk/government/publications/health-matters-obesity-and-the-food-environment/health-matters-obesity-and-the-food-environment--2#improving-everyones-access-to-healthier-food-choices Published 2017. Accessed August 5, 2023.

9. Public Health England. Chapter 3: trends in morbidity and risk factors. https://www.gov.uk/government/publications/health-profile-for-england-2018/chapter-3-trends-in-morbidity-and-risk-factors#diabetes Published 2018. Accessed August 2, 2023

10. National Health Service. Health Survey for England 2018. Adults' Health. London: Health and Social Care Information Centre. https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2018 Published 2019. Accessed August 3, 2023.

11. National Health Service Digital. Health Survey for England 2018: Population estimates user guide. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2018 Published 2019. Accessed July 31, 2023.

12. Public Health England. National Cardiovascular Intelligence Network. Prevalence estimates of Diabetes.

https://www.gov.uk/government/publications/diabetes-prevalence-estimates-for-local-populations Published 2016. Accessed, July 29, 2023.

13. Public Health England. Diabetes Prevalence Model. London: PHE. Available from: https://www.gov.uk/government/publications/diabetes-prevalence-estimates-for-local-populations Published 2016. Accessed, August 11, 2023.

14. National Health Service. Health Survey for England 2018. Overweight and obesity in adults and children. London: Health and Social Care Information Centre. https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2018 Published 2019. Accessed August 1, 2023.

15. Meigs, JB. (2010). Epidemiology of Type 2 Diabetes and Cardiovascular Disease: Translation From Population to Prevention. *Diabetes Care.* 2010;33(8): 1865-1871. https://care.diabetesjournals.org/content/33/8/1865 Accessed August 3, 2023.

16. National Heart, Lung, and Blood Institute (NHLBI). Three generations of Research on Heart Diseases. https://www.framinghamheartstudy.org/ Published 2023. Accessed June 18, 2023.

17. Lusignan S, Sismanidis C, Carey IM, et al. Trends in the prevalence and management of diagnosed type 2 diabetes 1994–2001 in England and Wales. *BMC Fam Pract.* 2005; 6:13. https://bmcprimcare.biomedcentral.com/articles/10.1186/1471-2296-6-13#citeas Accessed August 12, 2023.

18. Holman N, Forouhi NG, Goyder E, et al. The Association of Public Health Observatories (APHO) Diabetes Prevalence Model: estimates of total diabetes prevalence for England, 2010-2030. *Diabet Med.* 2011; 28(5): 575-82. https://onlinelibrary.wiley.com/doi/10.1111/j.1464-5491.2010.03216.x Accessed August 10, 2023.

19. Imkampe AK, Gulliford MC. Increasing socio-economic inequality in type 2 diabetes prevalence--repeated cross-sectional surveys in England 1994-2006. *Eur J Public Health.* 2011; 21(4): 484-90. https://pubmed.ncbi.nlm.nih.gov/20685812/ Accessed June 30, 2023.

20. Chung GK, Chung RY, Chan DC, Lai FT, Wong H, Lau MK, Wong SY, Yeoh EK. The independent role of deprivation in abdominal obesity beyond income poverty. A population-based household survey in Chinese adults. *J Public Health (Oxf).* 2019 30; 41(3):476-486. https://pubmed.ncbi.nlm.nih.gov/30215743/ Accessed July 30, 2023.

21. Feuillet T, Vallete JF, Charriere H, et al (2020). Influence of the urban context on the relationship between neighbourhood deprivation and obesity. *Soc Sci Med.* 2020; 265: 113537. https://www.sciencedirect.com/science/article/abs/pii/S0277953620307565 Accessed August 4, 2023.

22. Public Health England. Diabetes prevalence estimates for local authorities. London: PHE. https://www.gov.uk/government/publications/diabetes-prevalence-estimates-for-local-populations Published 2023. Accessed July 30, 2023.

23. Public Health England. Local Authority Health Profiles. Available from: https://fingertips.phe.org.uk/profile/health-profiles Published 2023. Accessed July 27, 2023.

24. Office for National Statistics. Mortality statistics- Underlying cause, sex and age.

https://www.nomisweb.co.uk/query/construct/summary.asp?reset=yes&mode=construct&dataset=161&version=0&anal=1&initsel= Published 2023. Accessed August 13, 2023.

25. National Health Service Digital. Hospital Admitted Patient Care Activity, 2021-22. https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2021-22 Published 2022. Accessed July 31, 2023.

26. Woodward, Mark. Epidemiology: Study Design and Data Analysis, 3rd edition. Boca Raton: CRC Press. https://online.vitalsource.com/#/books/9781439839713/cfi/6/10!/4/10/26/14/2/2/2@0:0 c2014. Accessed September 13, 2020.

27. Bruce N, Pope D, Stanistreet D. Quantitative methods for health research. A Practical Interactive Guide to Epidemiology and Statistics. Chichester: Wiley-Blackwell. c2008. https://www.vlereader.com/Reader?ean=9780470022764 Accessed September 14, 2021.

28. National Health Service Digital. National Diabetes Audit: Young People with Diabetes. https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-audit-yt2 Published 2023. Accessed August 14, 2023.

29. Lim CY, In J. Randomization in clinical studies. *Korean J Anesthesiol.* 2019; 72(3): 221-232. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6547231/ Accessed August 13, 2023.

30. Pop B, Fetica B, Blaga ML, et al. The role of medical registries, potential applications and limitations. *Med Pharm Rep.* 2019; 92(1): 7-14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6448488/ Accessed August 8, 2023.

31. Bonita R, Beaglehole R, Kiellstrom T. *Basic Epidemiology.* Geneva: WHO Press. c2012. https://rl.talis.com/3/essex/lists/FEE24BB6-E10B-385C-1484-AAB365FA5EBC.html?lang=en-GB Accessed September 13, 2021.

32. Bhopal RS. Concepts of Epidemiology: Integrating the ideas, theories, principles, and methods of epidemiology (3rd ed.) New York: Oxford University Press. c2016. https://0oxfordmedicinecom.serlib0.essex.ac.uk/view/10.1093/med/9780198739685.001.0001/med-9780198739685 Accessed August 31, 2021.

33. Thygesen L.G, Ersboll A.K. When the entire population is the sample: strengths and limitations in register-based epidemiology. *Eur J Epidemiol* 2014; 29(8): 551-558. http://www.jstor.org/stable/43775005 Accessed August 16, 2023.

34. Mooney SJ, Westreich DJ, El-Sayed AM. Epidemiology in the Era of Big Data. *Epidemiology.* 2015; 26(3): 390-394. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4385465/ Accessed August 9, 2023.

35. Green J, Tones K, Cross R., et al. Health Promotion: Planning and Strategies. Edition: 4th. London: SAGE. c2019. https://online.vitalsource.com/#/books/9781526470980/cfi/6/30!/4/2/4/2@0:0 Accessed September 13, 2021.

36. Abramson JH, Abramson ZH. (2001) New York: Oxford University Press. Making sense of data: A Self-Instruction Manual on the Interpretation of Epidemiological data. c2001. https://0-oxford-universitypressscholarship-com.serlib0.essex.ac.uk/view/10.1093/acprof:oso/9780195145250.001.0001/acprof-9780195145250-chapter-2 Accessed September 9, 2021.

37. Cotti C, Tefft, N. Fast food prices, obesity, and the minimum wage. *Econ Hum Biol.* 2013; *11*(2): 134-147. https://www.sciencedirect.com/science/article/abs/pii/S1570677X12000585 Accessed August 14, 2023.

38. Mortensen A. Sweeteners permitted in the European Union: safety aspects. *Scand J Food Nutr.* 2006; 50(3): 104–116. https://doi.org/10.3402/fnr.v50i3.1588 Accessed August, 9, 2023.

39. Johnston CA, Stevens B, Foreyt JP.The Role of Low-calorie Sweeteners in Diabetes. *Eur Endocrinol.* 2013; 9(2):96-98. https://pubmed.ncbi.nlm.nih.gov/29922361/ Accessed August 17, 2023.

40. Coca-Cola®. Coca Cola Store Online. https://us.coca-cola.com/products/coca-cola/original# Published 2022. Accessed April 24, 2022.