Supplementary File

Appendix 1 – Matching variables

The following variables were included in a propensity score model to match Knowsley to control areas in the time period before the introduction of the intervention (2005–09).

Matching variable	Details
Age and gender profile of the population	Annual data on the size of the female population and the population aged 50+ years per lower super output area (LSOA) were derived from mid-year population estimates provided by the Office for National Statistics (ONS).
Unemployment rate	Annual unemployment rates were calculated using claimant data provided by the ONS. Unemployment was measured as the number of people aged 16–64 years claiming Jobseeker's Allowance.
Cardiovascular disease (CVD) emergency admission rate	Emergency admissions for CVD were defined using ICD-10 codes: I00–99. Annual CVD emergency admission rates per 100,000 population were calculated using Hospital Episode Statistics (HES), with population data obtained from the ONS. Continuous inpatient (CIP) spells were used to calculate emergency admissions per calendar year.
Indices of Multiple Deprivation	Index of Multiple Deprivation 2015 data were provided by the Department for Communities and Local Government.
Quality and Outcomes Framework (QOF) indicators	QOF indicator data for the prevalence of coronary heart disease and smoking, and the percentage of patients with hypertension with blood pressure readings of 150/90mmHg or less were included in the propensity score model. Weighted averages of QOF indicators per LSOA were calculated using data provided by NHS Digital on the number of patients registered per general practice per LSOA.
Numbers of general practitioners (GPs) per capita serving the population	Weighted averages of the number of full-time employed GPs per 1000 population were calculated using data provided by NHS Digital on the number of GPs and patients registered per general practice per LSOA.
Distance to the nearest general practice and hospital	The Consumer Data Research Centre provided data per LSOA on the average road network distance to the nearest hospital with an Accident and Emergency (A&E) department, and the nearest general practice. Road network distances in kilometres were calculated by deriving the fastest route by car to travel from each postcode within an LSOA to the nearest health service.

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Appendix 2 - Statistical Analysis

Our sample size was predetermined based on the number of LSOAs in the intervention area and the number of matched LSOAs. Prior to our analysis however we estimated the effect size that the study would be able to detect with an 80% power by running multiple simulations of the planned analysis.[1] This indicated that the study had 80% power to detect an effect size between 6-7% decline in emergency admission rates associated with the intervention (see Supplementary file, Appendix 3).

Characteristics of the intervention and control populations prior to the intervention were initially compared to assess the balance achieved between the groups. Additionally, the parallel trends assumption was tested using graphical methods and regression models to compare trends in the outcomes of interest between the intervention and control populations in the pre-intervention period.

To estimate the difference-in-differences, i.e. the difference between the change in outcomes before and after the intervention in the intervention population compared to the change in outcomes over the same time periods in the control population, we include a treatment by period interaction term in a linear regression model. To control for potential demographic and socioeconomic changes which may confound the result we included annual LSOA data on unemployment rates, the percentage of the population that were female and the percentage aged 50+ years in the model. We included spline terms for time to assess the change in the trend after the intervention and a random intercept for each LSOA to account for the longitudinal nature of the data.

Data sources and measures

We used Hospital Episode Statistics (HES) and Office for National Statistics (ONS) population estimates to derive our primary outcome CVD (ICD-10 codes: I00–99) emergency hospital admissions per 100,000 population for each of the 588 LSOAs between 2005 and 2015 giving a total sample size of 6468 LSOA-years.[2 3] Secondary outcomes were length of stay per emergency admission and emergency readmission rates, also derived from HES data. Readmissions were defined as emergency admissions occurring within 30 days of the last, previous discharge from hospital.[4]

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These outcomes reflected the indicators agreed by the commissioner in their contract with the service provider. They were therefore the planned outcomes of the intervention. To adjust for time varying factors that could be associated with trends in CVD emergency admission rates, we controlled for the annual percent of the population aged 50+ years, the percent female, and the percent unemployed, using data obtained from the ONS.

Equation for multivariable mixed effects linear regression model for CVD emergency admissions

$$Y_{ij} = \beta_{0j} + \beta_{1j}t_{ij} + \beta_{2j}T_{ij} + \beta_{3j}Age_{ij} + \beta_{4j}Sex_{ij} + \beta_{5j}Unemployment_{ij} + \beta_{6j}Treatment_{ij} + \beta_{7j}Period_{ij} + \beta_{8j}Treatment_{ij}*Period_{ij} + \varepsilon_{ij}$$

Where Y_{ij} is the CVD emergency admission rate per 100,000 population for LSOA *i* at year *j*. The intercept β_{0j} contains a random effect term and thus varies across years. *t* is an annual time-trend term (spline 1). *T* is a time-trend term (spline 2) which captures the change in trend from year 2010, and is equal to zero prior to 2010. *Age* is the percent of the population aged 50+ years. *Sex* is the percent of the population who are female. *Unemployment* is the percent of the working age population (aged 16–64 years) claiming Jobseeker's Allowance. *Treatment* indicates whether LSOA *i* is a Knowsley or control LSOA (Knowsley = 1; control = 0). *Period* indicates whether year *j* occurs post or pre-intervention (post-intervention = 1; pre-intervention = 0). *Treatment*Period* is the difference-in-differences estimator.

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Characteristics of Knowsley and unmatched North West LSOAs in pre-intervention period (2005–09)

	Knowsley LSOAs (number = 98)	North West LSOAs (number = 4399)	
	mean (SD)	mean (SD)	p-value[a]
IMD score	41.99 (20.66)	26.51 (18.77)	<0.001
Distance to hospital with A&E (km)	5.47 (2.51)	7.46 (6.47)	<0.001
Distance to general practice (km)	1.09 (0.66)	1.29 (1.16)	0.238
Working age population unemployed (%)	4.74 (2.71)	2.84 (2.36)	<0.001
GPs per 1000 population	0.64 (0.12)	0.60 (0.12)	<0.001
Female population (number)	793.73 (128.70)	786.68 (139.03)	0.266
Population aged 50+ years (number)	493.08 (109.81)	529.96 (154.92)	<0.001
QOF: CHD prevalence (%)	4.67 (0.34)	4.17 (0.71)	<0.001
QOF: smoking prevalence (%)	25.83 (4.77)	20.39 (5.59)	<0.001
QOF: those with hypertension and blood pressure reading of 150/90mmHg or less (%)	80.30 (3.37)	78.66 (2.89)	<0.001
Emergency admissions for CVD per 100,000 population per year	1181.99 (508.49)	993.66 (445.25)	<0.001

[a] statistical significance of the difference between the groups tested using t-tests for normally distributed variables, or the Man-Whitney U test as a nonparametric equivalent
CHD = coronary heart disease; CVD = cardiovascular disease; GP = general practitioner; IMD = Index of Multiple Deprivation; km = kilometres; LSOA = Lower-layer Super Output Area; mmHg = millimetres of mercury; QOF = Quality and Outcomes Framework; SD = standard deviation

Emergency admission rates for CVD per 100,000 population per year

	Knowsley LSOAs (number = 98)			Control LSOAs (number = 490)		
Year	Mean	Lower 95% CI	Upper 95% CI	Mean	Lower 95% CI	Upper 95% CI
2005	1342.51	1234.30	1450.72	1271.97	1222.25	1321.69
2006	1267.58	1158.57	1376.58	1168.10	1119.55	1216.65
2007	1090.51	988.68	1192.33	1040.10	998.44	1081.76
2008	1100.65	1001.91	1199.38	1032.17	988.98	1075.35
2009	1054.60	973.85	1135.35	995.05	954.80	1035.31
2010	1116.14	1038.06	1194.21	986.96	949.60	1024.32
2011	992.44	909.19	1075.69	992.28	954.80	1029.77
2012	1045.66	964.64	1126.69	1027.85	988.64	1067.06
2013	1063.07	985.57	1140.58	1039.13	999.55	1078.72
2014	1204.86	1114.38	1295.35	1135.54	1095.66	1175.41
2015	1169.59	1077.49	1261.69	1119.09	1079.35	1158.84

CI = confidence interval; CVD = cardiovascular disease; LSOA = Lower-layer Super Output Area

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Result of difference-in-differences analysis showing the change in CVD emergency admissions per 100,000 population in Knowsley following the intervention relative to the control group, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-85.668	-92.75	-78.58	<0.001
Spline 2	142.782	129.70	155.87	<0.001
Population aged 50+ years (%)	29.293	26.86	31.72	<0.001
Population female (%)	5.875	-0.65	12.40	0.078
Working age population unemployed (%)†	315.597	263.94	367.26	<0.001
Treatment (Knowsley = 1; control = 0)	24.507	-35.56	84.58	0.423
Period (post-intervention = 1; pre-intervention = 0)	-59.916	-96.19	-23.64	0.001
DiD estimator (treatment*period)	-65.555	-108.98	-22.13	0.003

† Variable entered into model in units of 10% points
Model based on equation shown above and includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 6468 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

Analysis showing the change in CVD emergency admissions per 100,000 population per year in Knowsley relative to the control group in the pre-intervention period only (2005–09)

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Population aged 50+ years (%)	31.216	28.22	34.21	<0.001
Population female (%)	9.335	1.12	17.55	0.026
Working age population unemployed (%)†	510.647	442.09	579.21	<0.001
Treatment (Knowsley = 1; control = 0)	4.527	-71.19	80.25	0.907
Year	-96.222	-104.23	-88.21	<0.001
Treatment*year	1.225	-15.73	18.18	0.887

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 3528 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

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Analysis with interaction term to assess change in trend in CVD emergency admissions per 100,000 population between Knowsley and control groups post-intervention, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-85.716	-92.80	-78.63	<0.001
Spline 2	140.271	126.71	153.83	<0.001
Population aged 50+ years (%)	29.283	26.85	31.71	<0.001
Population female (%)	5.880	-0.65	12.41	0.078
Working age population unemployed (%)†	316.680	265.01	368.35	<0.001
Treatment (Knowsley = 1; control = 0)	24.453	-35.59	84.50	0.424
Period (post-intervention = 1; pre-intervention = 0)	-52.123	-90.04	-14.21	0.007
DiD estimator (treatment*period)	-113.607	-194.12	-33.09	0.006
Spline 2*treatment	16.030	-6.59	38.65	0.165

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 6468 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

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Appendix 3 - Power calculation

Simulation was used to estimate the power of the difference-in-differences analysis, based on the model formula given above. Power, i.e. the probability of rejecting a false null hypothesis, was estimated at specific effect sizes by running the model using multiple simulated datasets each with a specific relative effect size plus a random error drawn from a normal distribution in each iteration.[1] Power was then estimated as the proportion of the models which falsely rejected the null hypothesis. For each specified effect size, 100 simulated datasets were tested. The results are shown below and indicate that the effect size that the study had 80% power to detect, lay somewhere between 6-7% decline in emergency admissions associated with the intervention. In absolute terms this is the equivalent of a reduction of 71 to 83 emergency CVD admissions per 100,000 population.

Effect size	Proportion of models which rejected null hypothesis %
0.8	100
0.9	100
0.91	100
0.92	97
0.93	93
0.94	73
0.95	63
0.96	45
0.97	30
0.98	9
0.99	6

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Appendix 4 - Robustness tests

We investigated the presence of unobserved confounding by repeating the analysis using an outcome that would not be expected to be influenced by the CVD intervention, i.e. emergency admissions for gastrointestinal (GI) infections. Additionally, we repeated the analysis using an alternative control group with controls selected from LSOAs outside the North West. We also investigated whether the effect of the intervention was different in more deprived LSOAs compared to less deprived LSOAs within Knowsley, and whether the effect differed between men and women. Analyses were conducted using statistical software R (version 3.4.3).

Result of difference-in-differences analysis showing the change in gastrointestinal infection emergency admissions per 100,000 population in Knowsley following the intervention relative to the control group, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	14.416	10.80	18.03	<0.001
Spline 2	-10.349	-16.76	-3.94	0.002
Population aged 50+ years (%)	-1.164	-2.02	-0.31	0.008
Population female (%)	6.476	3.94	9.02	<0.001
Working age population unemployed (%)†	127.688	106.28	149.10	<0.001
Treatment (Knowsley = 1; control = 0)	22.536	2.02	43.05	0.031
Period (post-intervention = 1; pre-intervention = 0)	-97.097	-115.99	-78.21	<0.001
DiD estimator (treatment*period)	-17.438	-40.40	5.53	0.137

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 6468 observations
CI = confidence interval; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

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Result of difference-in-differences analysis showing the change in CVD emergency admissions per 100,000 population in Knowsley following the intervention relative to the control group, with controls selected from outside the North West region of England, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-70.935	-78.64	-63.23	<0.001
Spline 2	95.862	81.98	109.75	<0.001
Population aged 50+ years (%)	30.009	27.48	32.53	<0.001
Population female (%)	11.326	4.03	18.62	0.002
Working age population unemployed (%)†	269.685	215.03	324.34	<0.001
Treatment (Knowsley = 1; control = 0)	-10.973	-74.63	52.68	0.735
Period (post-intervention = 1; pre-intervention = 0)	-18.915	-57.61	19.78	0.338
DiD estimator (treatment*period)	-49.153	-95.09	-3.22	0.036

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 6468 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

Result of difference-in-differences analysis showing the change in CVD emergency admissions per 100,000 population in Knowsley following the intervention relative to the control group, with IMD income deprivation tertile interaction term, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-76.727	-83.83	-69.62	<0.001
Spline 2	111.263	97.42	125.11	<0.001
Population aged 50+ years (%)	31.496	29.19	33.80	<0.001
Population female (%)	-1.724	-7.90	4.45	0.584
Working age population unemployed (%)†	100.091	39.05	161.13	0.001
Treatment (Knowsley = 1; control = 0)	28.043	-69.01	125.10	0.571
Period (post-intervention = 1; pre-intervention = 0)	23.914	-19.75	67.58	0.283
Income deprivation tertile: medium[a]	327.557	272.41	382.70	<0.001
Income deprivation tertile: high[a]	467.419	402.13	532.71	<0.001
DiD estimator (treatment*period)	-12.046	-90.03	65.94	0.762
Treatment* income deprivation tertile: medium[a]	-63.497	-201.50	74.50	0.367
Treatment* income deprivation tertile: high[a]	10.872	-117.95	139.70	0.868
Period* income deprivation tertile: medium[a]	-7.352	-50.12	35.41	0.736
Period* income deprivation tertile: high[a]	-120.549	-164.54	-76.56	<0.001
Treatment*period* income deprivation tertile: medium[a]	-78.193	-189.27	32.88	0.168
Treatment*period* income deprivation tertile: high[a]	-57.911	-161.41	45.59	0.273

† Variable entered into model in units of 10% points
[a] Reference category = Income deprivation: low
Model includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 6468 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; IMD = Index of Multiple Deprivation; LSOA = Lower-layer Super Output Area

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Result of difference-in-differences analysis showing the change in CVD emergency admissions per 100,000 population in Knowsley following the intervention relative to the control group, with gender interaction term, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-86.693	-93.83	-79.55	<0.001
Spline 2	143.980	130.73	157.23	<0.001
Population aged 50+ years (%)	29.545	27.10	31.99	<0.001
Working age population unemployed (%)†	321.047	268.76	373.33	<0.001
Treatment (Knowsley = 1; control = 0)	66.073	-0.85	133.00	0.053
Period (post-intervention = 1; pre-intervention = 0)	-63.485	-104.41	-22.56	0.002
Sex (female = 1; male = 0)	-231.331	-255.51	-207.16	<0.001
DiD estimator (treatment*period)	-105.963	-168.13	-43.80	0.001
Treatment*sex	-56.706	-115.92	2.51	0.061
Period*sex	3.744	-32.11	39.60	0.838
Treatment*period*sex	79.891	-7.94	167.73	0.075

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 98 Knowsley and 490 control LSOAs, and 12936 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

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Appendix 5 - Length of stay per emergency admission

LSOAs which had zero CVD emergency admissions for any year of the study period were removed when analysing the length of stay outcome, since length of stay was not applicable when zero admissions occurred.

Result of difference-in-differences analysis showing the change in length of stay in days per emergency CVD admission in Knowsley following the intervention relative to the control group, 2005–15

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-0.577	-0.85	-0.30	<0.001
Spline 2	0.339	-0.14	0.81	0.162
Population aged 50+ years (%)	0.039	-0.01	0.09	0.100
Population female (%)	-0.051	-0.19	0.09	0.477
Working age population unemployed (%)†	-0.307	-1.51	0.90	0.617
Treatment (Knowsley = 1; control = 0)	-2.008	-3.28	-0.74	0.002
Period (post-intervention = 1; pre-intervention = 0)	-0.964	-2.43	0.50	0.197
DiD estimator (treatment*period)	1.037	-0.77	2.84	0.260

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 97 Knowsley and 489 control LSOAs, and 6446 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

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Appendix 6 - Emergency readmission rates

LSOAs which had zero CVD emergency admissions for any year of the study period were removed when analysing the emergency readmission rate outcome.

Result of difference-in-differences analysis showing the change in CVD emergency readmissions per 100,000 population in Knowsley following the intervention relative to the control group, 2005–2015

	Coefficient	Lower 95% CI	Upper 95% CI	p-value
Spline 1	-7.648	-8.98	-6.32	<0.001
Spline 2	12.860	10.51	15.21	<0.001
Population aged 50+ years (%)	1.591	1.30	1.88	<0.001
Population female (%)	-0.214	-1.06	0.63	0.620
Working age population unemployed (%)†	28.922	21.79	36.05	<0.001
Treatment (Knowsley = 1; control = 0)	-0.910	-8.16	6.34	0.805
Period (post-intervention = 1; pre-intervention = 0)	-6.980	-14.01	0.05	0.052
DiD estimator (treatment*period)	-4.907	-13.51	3.69	0.263

† Variable entered into model in units of 10% points
Model includes random intercept for LSOA
Model based on 97 Knowsley and 487 control LSOAs, and 6424 observations
CI = confidence interval; CVD = cardiovascular disease; DiD = Difference-in-Differences; LSOA = Lower-layer Super Output Area

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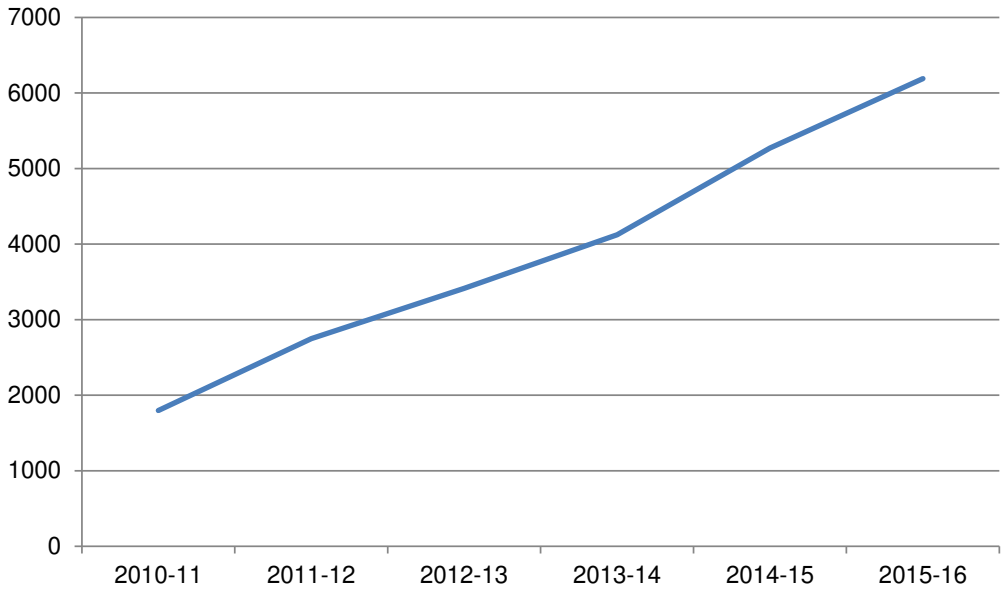
Appendix 7 – Intervention details

Total number of general practice patient referrals to the Knowsley CVD intervention per year, 2010–15



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Appendix 8 – Outline of the Difference-in-Differences analysis used in the study

Difference-in-differences (DiD) analyses are an established approach used in econometrics[5 6] and increasingly in health research[7 8] for evaluating the impact of interventions, where the researcher has not manipulated the assignment of the intervention, sometimes known as "natural experiments".

In DiD analyses, outcomes are observed for two groups before and after an intervention and one of the groups is exposed to a treatment in the second period but not in the first period, and the second group is not exposed to the treatment during the full time frame. The average change in outcomes in the second (control) group is then subtracted from the average change in outcomes the first (treatment) group. This removes biases in second period comparisons between the treatment and control group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the treatment group that could be the result of trends.

Thus the differences-in-differences estimator is therefore:

$$\hat{\gamma} = \left(\bar{Y}_{Treatment,AFTER} - \bar{Y}_{Treatment,BEFORE}\right) - \left(\bar{Y}_{COMPARATOR,AFTER} - \bar{Y}_{COMPARATOR,BEFORE}\right)$$

$\bar{Y}$ is the mean of the outcome variable in the intervention areas after the start of the intervention ($\bar{Y}_{Treatment,AFTER}$) and before the start of the intervention ($\bar{Y}_{Treatment,BEFORE}$) and in the comparator areas after the start of the intervention ($\bar{Y}_{COMPARATOR,AFTER}$) and before the start of the intervention ($\bar{Y}_{COMPARATOR,BEFORE}$). A representation of this is given in the figure below:

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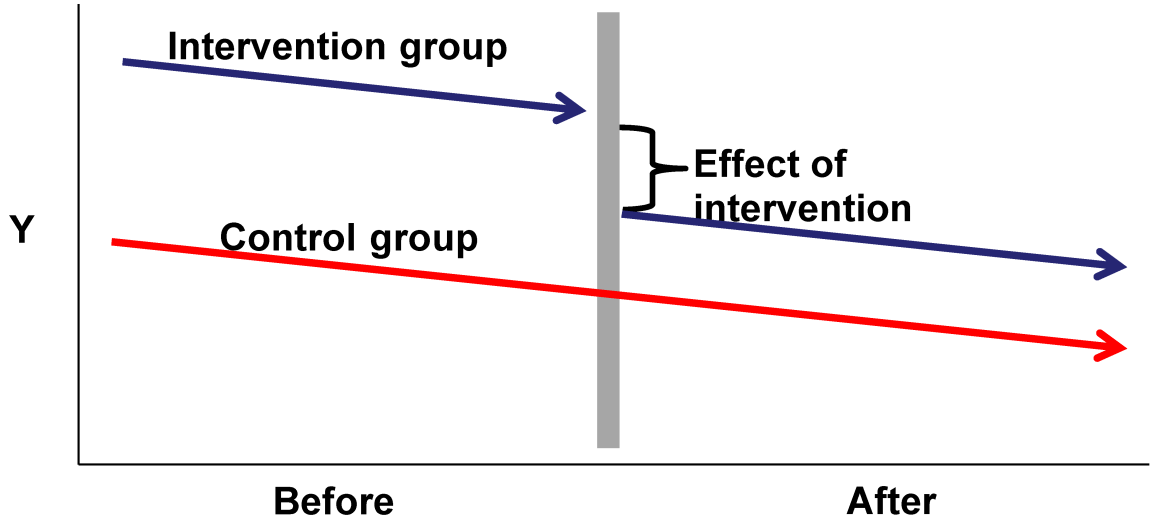

To estimate the DiD estimator we can run the following regression:

$$Y_{at} = \beta_1 Treatment_a + \beta_2 AFTER_t + \beta_3 AFTER_t * Treatment_a + \varepsilon_{at}$$

where Y_{at} is the outcome variable in area *a* at time *t*, $Treatment_a$ is a dummy variable taking the value 1 for the intervention area and the value 0 for the comparator areas and $AFTER_t$ is a dummy variable taking the value 1 for time periods after the start of the intervention and 0 before. The coefficient of interest is β_3, the coefficient on the interaction term $AFTER_t * BL_a$, this is the differences-in-differences parameter.

Whilst this analysis cannot be biased due to time invariant differences between the intervention and control groups, it could be biased by trends in other predictors of the outcome if these diverged between treatment and intervention groups after the intervention. We therefore additionally include potential time varying confounders in this model, giving the following model used in the analysis.

Mixed effects linear regression model for CVD emergency admissions:

Model 1:

$$Y_{ij} = \beta_{0j} + \beta_{1j}t_{ij} + \beta_{2j}T_{ij} + \beta_{3j}Age_{ij} + \beta_{4j}Sex_{ij} + \beta_{5j}Unemployment_{ij} + \beta_{6j}Treatment_{ij} + \beta_{7j}After_{ij} + \beta_{8j}Treatment_{ij}*After_{ij} + \varepsilon_{ij}$$

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Where Y_{ij} is the CVD emergency admission rate per 100,000 population for LSOA *i* at year *j*. The intercept β_{0j} contains a random effect term and thus varies across years. *t* is an annual time-trend term (spline 1). *T* is a time-trend term (spline 2) which captures the change in trend from year 2010, and is equal to zero prior to 2010. *Age* is the annual percent of the population aged 50+ years. *Sex* is the annual percent of the population who are female. *Unemployment* is the annual percent of the working age population (aged 16–64 years) claiming Jobseeker's Allowance. *Treatment* indicates whether LSOA *i* is a Knowsley or control LSOA (Knowsley = 1; control = 0). *After* indicates whether year *j* occurs post or pre-intervention (post-intervention = 1; pre-intervention = 0). *Treatment*After* is the difference-in-differences estimator.

The key assumption of difference-in-differences analysis is the parallel trends assumption. If the trend in the outcome in the intervention and control populations would have been parallel in the absence of the intervention then, the difference between the change in the outcomes between the two groups provides an unbiased estimate of the interventions effect.[9]

We use a linear regression model, as the interaction term can only be interpreted as the difference-in-differences estimator in a linear probability model, and linear models provide a robust estimate of the difference-in-difference estimator even when the data are not normally distributed.[10] An alternative approach is to use a log linear Poisson model, then to use this model to estimate the marginal difference-in-differences of the predicted outcome.[10] As a sensitivity test we additionally conduct the analysis using a Poisson model as described. We also investigate the parallel trends assumption testing for any divergence in trends between the two groups prior to the intervention.

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Comparing difference-in-difference estimator using alternative regression models - The estimates indicate the reduction in emergency admissions per 100,000 population in the intervention areas, after the intervention relative to the control areas

Model	Estimate	Lower 95% CI	Upper 95% CI	p-value
1. Linear regression (model 1 as above)	-65.08	-114.58	-15.59	.00995463
2. Poisson regression model	-70.62	-120.71	-20.53	.00571986
3. Negative Binomial model	-68.31	-110.22	-26.39	.00140316
4. Poisson regression model with additional random effect for each matched group of LSOAs	-69.54	-104.3	-34.78	.00008821

All models include random intercept for LSOA, and fixed effects for percent of population aged 50+ years, percent female, percent unemployed and two spline terms for time. Model 4 additionally includes a random effect for each matched group of LSOAs.

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