

Appendix

Methodology and supplementary data

Detailed methodology

Workforce data

We used primary care workforce data from the most recent release of the General Practice Workforce series published by NHS Digital for 31 March 2020.¹ This dataset includes details on all NHS GPs as well as all NHS GP practices operating in England. Data on individuals in this data series were used to categorise GPs by age, sex, country of qualification, primary job role and clinical commissioning group (CCG). The data series on GP practices was used to identify single-handed GP practices as those run by a single GP (excluding locums, registrars and retainers who may work at the practice). GPs and practices lacking data on GP age and sex were excluded as meaningful judgements on the risk of COVID-19 mortality could not be made without these key characteristics. This resulted in 1,615 (3.4%) of GPs and four (0.06%) single-handed GP practices being excluded from our dataset.

Age-specific COVID-19 mortality rates

Age- and sex-specific mortality data covering the period between 1 March 2020 and 30 April 2020 from the ONS were used to capture deaths from COVID-19.² This mortality data was combined with age- and sex-specific population data from ONS mid-year population estimates for 2019 to calculate age-sex specific COVID-19 mortality rates.³

Socioeconomic distribution of CCGs

The index of multiple deprivation (IMD) 2019 measures relative deprivation in small areas in England called lower-layer super output areas (LSOAs).⁴ We attributed IMD scores from LSOAs to CCGs by calculating population weighted averages, and used these attributed scores to rank CCGs into population-weighted deprivation quintile groups with each quintile group of CCGs covering approximately a fifth of the total population.^{5,6,7} A table detailing the CCG deprivation quintiles we calculated for use in this analysis is provided in Table 4.

COVID-19 risk reduction framework

We used the risk reduction framework for NHS staff at risk of COVID-19 infection to guide our understanding of key characteristics that contribute to the level of risk from COVID-19 faced by GPs.⁸ The framework highlights age, sex, ethnicity, underlying health conditions and pregnancy as the five most important factors that influence risk from COVID-19 among NHS staff. We also considered the safety assessment and decision (SAAD) score, designed to assess risks for all staff working within general practice during COVID-19, which highlights similar factors as contributing to mortality risk using a more detailed treatment of ethnicity and underlying health conditions.⁹ We characterised risk among GPs using the age groups and ethnicity categories suggested in the

framework. We were not able to obtain data regarding the ethnicity of GPs, so we used country of qualification as a proxy for ethnicity, counting GPs listed as qualifying either in the UK or the EEA as being white, while GPs listed as qualifying anywhere else were counted as black and minority ethnic. Our ethnicity variable therefore mis-categorises black and minority ethnic GPs who qualified in the UK or EEA as white and hence will under-estimate COVID-19 risk associated with these GPs. Data on underlying health conditions and pregnancy were not available in the workforce data so we were unable to include these in our analysis.

COVID-19 risk categorisation of GPs

We used the age-sex specific COVID-19 mortality rates we calculated to translate the risk reduction framework into a risk scoring system. Risk scores were calculated by dividing all mortality rates by those for women aged 55–60 (the lowest risk group for whom COVID-19 mortality risk is non-negligible). These scores were adjusted for ethnicity using a recent ONS study that found that age- and sex-adjusted COVID-19 mortality rates for non-white ethnic groups are between two times and four times those of white people depending on which non-white ethnic group is being compared.¹⁰ Two alternative sets of risk scores were calculated for black and minority ethnic GPs by using the upper and lower range of these ethnicity specific adjustments respectively to adjust the overall age-sex specific risk scores. We used the resulting risk scores to categorise both GPs and single-handed GP practices into four risk categories (low, medium, high and very high) to reflect the risk of mortality from COVID-19.

Outcome measures

Our main outcome measures were (1) numbers of GPs, (2) number of single-handed GP practices and (3) numbers of patients registered to single-handed GP practices. Each outcome measure was disaggregated by COVID-19 risk category to identify the numbers of GPs, single-handed practices and patients registered to single-handed practices at high and very high risk levels. The regional and socioeconomic distribution of high and very high COVID-19 risk in primary care was examined for each outcome measure.¹¹

Software

All analysis was conducted using R version 4.0.0 statistical software.¹²

Supplementary results relating to risk assessment framework

Age-sex specific COVID-19 mortality rates show that risk increases rapidly with age, with the risk of dying from COVID-19 in those older than 70 years of age being approximately a hundred times higher than risk for those younger than 55 years of age (see Table 1). Additionally, we see that at any given age, the risk for men is approximately double that for women.

Table 1: COVID-19 deaths by age and sex per 100,000 population

Age group	Sex	Population	COVID-19 deaths	COVID-19 deaths per 100,000 population
<55	Male	19,754,779	757	3.8
<55	Female	19,395,980	445	2.3
55-59	Male	1,809,613	650	35.9
55-59	Female	1,861,038	301	16.2
60-69	Male	2,880,038	2,143	74.4
60-69	Female	3,028,537	1,044	34.5
70+	Male	3,383,401	13,984	413.3
70+	Female	4,173,575	11,280	270.3

Note: population data from ONS 2019 mid-year populations, COVID-19 deaths from ONS deaths between 1 March 2020 and 30 April 2020

The results of converting these mortality rates into risk scores, and adding ethnicity specific adjustments to get risk scores A and B are shown in Table 2. In risk score A and B black and minority ethnic GPs have double or quadruple the risk of white GPs of the same age and sex respectively. Using either risk scoring system we find that GPs younger than 55 years of age – regardless of sex or ethnicity – are at the lowest risk, while those older than 70 years of age are at the highest risk. We categorise GPs into four categories based on these risk scores: low (0–1 points), medium (1–4), high (4–9) and very high (>9). Risk categories were defined to reflect discontinuities in the risk scores. Table 2 shows that the highest risk GPs in each of the risk categories is at approximately half the risk as the lowest risk GPs in the next risk category. The categorisation we have used works for both risk scores A and B and is robust to the choice of ethnicity adjustment.

Table 2: COVID-19 risk categorisation based on mortality risk

Age group	Sex	Ethnicity	Risk Score A (black and minority ethnic = 2*white)	Risk Score B (black and minority ethnic = 4*white)	COVID-19 Risk
70+	Male	Black and minority ethnic	51.1	102.2	very high
70+	Female	Black and minority ethnic	33.4	66.8	very high
70+	Male	White	25.6	25.6	very high
60-69	Male	Black and minority ethnic	9.2	18.4	very high
70+	Female	White	16.7	16.7	very high
55-59	Male	Black and minority ethnic	4.4	8.9	high
60-69	Female	Black and minority ethnic	4.3	8.5	high
60-69	Male	White	4.6	4.6	high
55-59	Female	Black and minority ethnic	2	4	medium
55-59	Male	White	2.2	2.2	medium
60-69	Female	White	2.1	2.1	medium
55-59	Female	White	1	1	low
<55	Male	Black and minority ethnic	0.5	0.9	low
<55	Female	Black and minority ethnic	0.3	0.6	low
<55	Male	White	0.2	0.2	low
<55	Female	White	0.1	0.1	low

Notes: Age groups based on those used in the NHS risk reduction framework. GPs with missing data on age, sex or ethnicity classed with COVID-19 risk level unknown.

Supplementary descriptive statistics for GPs included in our analysis

Table 3: Descriptive statistics for the 45,858 GPs and 639 single-handed GP practices in England

Characteristic	Number of GPs	Proportion of GPs (%)	Number of single hander practices	Proportion of single hander practices (%)
Age group				
<55	38,141	83.2%	330	51.6%
55-59	3,853	8.4%	111	17.4%
60-69	3,238	7.1%	117	18.3%
70+	626	1.4%	81	12.7%
Gender				
Female	25,603	55.8%	194	30.4%
Male	20,255	44.2%	445	69.6%
Country of qualification				
UK & EEA	34,877	76.1%	405	63.4%
Other	10,981	23.9%	234	36.6%
Job role				
GP partners	20,979	45.7%	639	100%
Salaried GPs	13,519	29.5%	-	-
GP Locums	4,484	9.8%	-	-
GP Registrars	6,339	13.8%	-	-
GP Retainers	537	1.2%	-	-

COVID-19 risk group				
Low	39,543	86.2%	348	54.5%
Medium	2,683	5.9%	82	12.8%
High	2,253	4.9%	95	14.9%
Very high	1,379	3.0%	114	17.8%
Region				
East of England	4,600	10.0%	67	10.5%
London	7,675	16.7%	131	20.5%
Midlands	8,445	18.4%	144	22.5%
North-east and Yorkshire	6,815	14.9%	97	15.2%
North-west	5,782	12.6%	136	21.3%
South-east of England	6,851	14.9%	58	9.1%
South-west of England	4,927	10.7%	6	0.9%
Unknown	763	1.7%	-	-
IMD quintile				
Q1 most deprived	9,331	20.3%	239	37.4%
Q2	8,713	19.0%	146	22.8%
Q3	9,332	20.3%	111	17.4%
Q4	8,707	19.0%	84	13.1%
Q5 least deprived	9,012	19.7%	59	9.2%
Unknown	763	1.7%	-	-

Notes: Data from the NHS Digital General Practice Workforce for 31 March 2020, COVID-19 risk scores: low (0–1), medium (1–4), high (4–9), very high (>9), IMD = index of multiple deprivation 2019 population weighted ranks at CCG level.

Table 4: Population, IMD 2019 score and IMD 2019 quintile for Clinical Commissioning Groups as of April 2020

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
00R	NHS Blackpool CCG	139,305	45.39	1
01J	NHS Knowsley CCG	149,571	43.14	1
99A	NHS Liverpool CCG	494,814	42.44	1
03F	NHS Hull CCG	260,645	40.58	1
14L	NHS Manchester CCG	547,627	39.87	1
05L	NHS Sandwell and West Birmingham CCG	504,641	37.78	1
00Q	NHS Blackburn with Darwen CCG	148,942	36.15	1
01D	NHS Heywood, Middleton and Rochdale CCG	220,001	34.67	1
01G	NHS Salford CCG	254,408	34.32	1
05W	NHS Stoke on Trent CCG	264,149	33.99	1
00Y	NHS Oldham CCG	235,623	33.69	1
15E	NHS Birmingham and Solihull CCG	1,179,020	33.62	1

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
36J	NHS Bradford District and Craven CCG	587,936	32.93	1
01T	NHS South Sefton CCG	159,237	32.79	1
07L	NHS Barking and Dagenham CCG	211,998	32.74	1
06A	NHS Wolverhampton CCG	262,008	32.41	1
01F	NHS Halton CCG	128,432	32.34	1
05Y	NHS Walsall CCG	283,378	32.07	1
07T	NHS City and Hackney CCG	288,371	32.03	1
01X	NHS St Helens CCG	180,049	31.69	1
00N	NHS South Tyneside CCG	150,265	31.68	1
03H	NHS North East Lincolnshire CCG	159,821	31.34	1
00T	NHS Bolton CCG	285,372	31.03	1
16C	NHS Tees Valley CCG	674,284	30.96	1
04C	NHS Leicester City CCG	355,218	30.84	1
00P	NHS Sunderland CCG	277,417	30.70	1
02X	NHS Doncaster CCG	310,542	30.46	1

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
02P	NHS Barnsley CCG	245,199	29.99	1
01Y	NHS Tameside and Glossop CCG	258,613	29.75	1
12F	NHS Wirral CCG	323,235	29.73	1
01A	NHS East Lancashire CCG	380,013	29.63	1
03L	NHS Rotherham CCG	264,671	29.63	1
08M	NHS Newham CCG	352,005	29.49	1
13T	NHS Newcastle Gateshead CCG	502,704	29.28	1
03J	NHS North Kirklees CCG	192,750	28.88	1
08V	NHS Tower Hamlets CCG	317,705	27.63	2
15F	NHS Leeds CCG	789,194	27.58	2
03R	NHS Wakefield CCG	345,038	27.36	2
03N	NHS Sheffield CCG	582,506	27.25	2
10R	NHS Portsmouth CCG	215,133	27.20	2
10X	NHS Southampton CCG	252,796	26.88	2
84H	NHS County Durham CCG	526,980	26.61	2

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
02T	NHS Calderdale CCG	210,082	26.46	2
06P	NHS Luton CCG	214,109	26.05	2
02H	NHS Wigan Borough CCG	326,088	25.89	2
07P	NHS Brent CCG	330,795	25.66	2
08W	NHS Waltham Forest CCG	276,700	25.24	2
05X	NHS Telford and Wrekin CCG	177,799	24.99	2
05C	NHS Dudley CCG	320,626	24.31	2
01E	NHS Greater Preston CCG	202,562	24.07	2
00V	NHS Bury CCG	190,108	23.92	2
52R	NHS Nottingham and Nottinghamshire CCG	1,037,356	23.68	2
10L	NHS Isle of Wight CCG	141,538	23.33	2
05A	NHS Coventry and Rugby CCG	473,979	23.27	2
11N	NHS Kernow CCG	568,210	23.01	2
93C	NHS North Central London CCG	1,498,001	22.97	2
07W	NHS Ealing CCG	341,982	22.75	2

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
02Q	NHS Bassetlaw CCG	116,839	22.75	2
06T	NHS North East Essex CCG	338,326	22.68	2
03A	NHS Greater Huddersfield CCG	245,977	22.56	2
99G	NHS Southend CCG	182,463	22.55	2
08C	NHS Hammersmith and Fulham CCG	185,426	22.33	2
08Y	NHS West London CCG	226,099	22.28	2
72Q	NHS South East London CCG	1,811,249	22.25	3
03K	NHS North Lincolnshire CCG	172,005	22.22	3
99C	NHS North Tyneside CCG	205,985	22.22	3
00L	NHS Northumberland CCG	320,274	22.08	3
05H	NHS Warwickshire North CCG	193,752	21.80	3
01H	NHS North Cumbria CCG	318,631	21.79	3
01K	NHS Morecambe Bay CCG	330,572	21.72	3
26A	NHS Norfolk & Waveney CCG	1,021,991	21.72	3
07Y	NHS Hounslow CCG	270,782	21.57	3

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
07G	NHS Thurrock CCG	172,525	21.08	3
01W	NHS Stockport CCG	291,775	20.99	3
09D	NHS Brighton and Hove CCG	290,395	20.86	3
15M	NHS Derby and Derbyshire CCG	1,019,900	20.51	3
91Q	NHS Kent and Medway CCG	1,846,478	20.36	3
71E	NHS Lincolnshire CCG	755,833	20.27	3
15N	NHS Devon CCG	1,194,166	20.17	3
97R	NHS East Sussex CCG	554,590	19.80	3
15C	NHS Bristol, North Somerset and South Gloucestershire CCG	959,968	19.72	3
01V	NHS Southport and Formby CCG	116,159	19.51	4
99E	NHS Basildon and Brentwood CCG	262,412	19.49	4
04Y	NHS Cannock Chase CCG	136,974	19.28	4
02E	NHS Warrington CCG	209,547	19.05	4
78H	NHS Northamptonshire CCG	730,650	18.78	4
02M	NHS Fylde and Wyre CCG	192,421	18.66	4

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
02G	NHS West Lancashire CCG	113,949	18.61	4
11X	NHS Somerset CCG	559,399	18.60	4
09A	NHS Central London (Westminster) CCG	185,422	18.55	4
08G	NHS Hillingdon CCG	304,824	18.36	4
18C	NHS Herefordshire and Worcestershire CCG	784,164	18.32	4
05D	NHS East Staffordshire CCG	128,418	18.25	4
04F	NHS Milton Keynes CCG	275,002	17.77	4
06L	NHS Ipswich and East Suffolk CCG	409,248	17.72	4
00X	NHS Chorley and South Ribble CCG	176,862	17.70	4
05G	NHS North Staffordshire CCG	219,571	17.62	4
08N	NHS Redbridge CCG	303,858	17.30	4
05N	NHS Shropshire CCG	320,274	17.13	4
11J	NHS Dorset CCG	772,268	17.05	4
08F	NHS Havering CCG	257,810	17.03	4
10V	NHS South Eastern Hampshire CCG	216,379	16.94	4

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
06H	NHS Cambridgeshire and Peterborough CCG	889,112	16.85	4
27D	NHS Cheshire CCG	721,292	16.21	4
02A	NHS Trafford CCG	236,370	16.13	4
02Y	NHS East Riding of Yorkshire CCG	317,404	16.09	4
07K	NHS West Suffolk CCG	230,997	15.99	4
36L	NHS South West London CCG	1,494,905	15.99	4
42D	NHS North Yorkshire CCG	426,821	15.65	4
05Q	NHS South East Staffordshire and Seisdon Peninsula CCG	226,137	15.52	5
07H	NHS West Essex CCG	306,910	15.16	5
08E	NHS Harrow CCG	250,149	15.10	5
11M	NHS Gloucestershire CCG	633,558	14.94	5
06F	NHS Bedfordshire CCG	455,229	14.75	5
70F	NHS West Sussex CCG	858,852	14.44	5
92G	NHS Bath and North East Somerset, Swindon and Wiltshire CCG	918,428	14.28	5
15D	NHS East Berkshire CCG	434,463	13.99	5

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
10K	NHS Fareham and Gosport CCG	201,622	13.96	5
06K	NHS East and North Hertfordshire CCG	569,078	13.80	5
99F	NHS Castle Point and Rochford CCG	177,051	13.70	5
06Q	NHS Mid Essex CCG	393,065	13.56	5
05V	NHS Stafford and Surrounds CCG	155,803	13.55	5
04V	NHS West Leicestershire CCG	402,165	13.29	5
10J	NHS North Hampshire CCG	223,795	12.12	5
03Q	NHS Vale of York CCG	362,955	11.96	5
06N	NHS Herts Valleys CCG	595,670	11.94	5
05R	NHS South Warwickshire CCG	270,064	11.89	5
15A	NHS Berkshire West CCG	489,709	11.80	5
10Q	NHS Oxfordshire CCG	672,414	11.72	5
11A	NHS West Hampshire CCG	566,879	11.37	5
03W	NHS East Leicestershire and Rutland CCG	335,800	10.78	5
99M	NHS North East Hampshire and Farnham CCG	211,590	10.40	5

CCG code	CCG name (from April 2020)	Population (mid-2018)	IMD 2019 score	IMD 2019 quintile
92A	NHS Surrey Heartlands CCG	1,036,742	10.32	5
14Y	NHS Buckinghamshire CCG	542,512	10.15	5
10C	NHS Surrey Heath CCG	96,474	9.24	5

Note: We calculated population weighted quintile groups ie five groups of CCGs with approximately equal populations – with quintile 1 being the most deprived and quintile 5 being the most affluent group.

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