

How have patterns of social mixing changed during the pandemic?

A series of cross-sectional nationally representative surveys

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Abstract

Social mixing contributes to the transmission of SARS-CoV-2. We developed a composite measure for risky social mixing, investigating changes during the pandemic and factors associated with risky mixing. Twenty-eight waves of online nationally representative cross-sectional surveys were used (n=47,933 responses; 14 September 2020 to 10 August 2021). We investigated socio-demographic, contextual and psychological factors associated with engaging in highest risk social mixing at six timepoints. Patterns of social mixing varied over time, broadly in line with changes in restrictions. Engaging in highest risk social mixing was associated with being younger, less worried about COVID-19, perceiving a lower risk of COVID-19, perceiving COVID-19 to be a less severe illness, thinking the risks of COVID-19 were being exaggerated, not agreeing that one's personal behaviour had an impact on how COVID-19 spreads, and not agreeing that information from the Government about COVID-19 can be trusted. Our composite measure for risky social mixing varied in line with restrictions in place at the time of data collection, providing some validation of the measure. While messages targeting psychological factors may reduce higher risk social mixing, achieving a large change in risky social mixing in a short space of time may necessitate a reimposition of restrictions.

Abstract word count: 199/200 words

Key words: COVID-19; contact behaviour; social distancing; physical distancing; socialising

Introduction

Behavioural strategies to prevent the spread of SARS-CoV-2 have focused on reducing the number of contacts made in everyday life through policies requiring people to work from home where possible, avoid hospitality and leisure venues, and remain physically distant from each other. This is an effective way of decreasing transmission.¹ In England, there have been a series of national restrictions limiting social contact (Table 1). In some cases, social mixing was only allowed in outdoor spaces, due to evidence suggesting that transmission is lower in more ventilated areas.^{2,3} Compared to before the pandemic, people's contacts were reduced between March 2020 and March 2021, with contact patterns changing in line with UK Government recommendations.⁴

Table 1. Restrictions on social mixing in England during the pandemic (March 2020-July 2021)

Date	Restriction	Setting	Social contact allowed	Number of people from other households allowed	Distancing
16 March 2020	People asked to stay at home	All settings	Yes	Not specified	Not specified
23 March 2020	First national lockdown	All settings	No	N/A	N/A
13 May 2020	Lockdown restrictions eased	Outdoor public spaces	Yes	One	2m+
4 July 2020	Hospitality reopens	Outdoors	Yes	Five	1m+
		Indoors	Yes	Not specified, from one other household	1m+
14 September 2020	Rule of six	Outdoors	Yes	Five	Not specified
		Indoors	Yes	Five	Not specified
14 October 2020	Tiers (local COVID-19 alert level): 1 (medium):	Outdoors	Yes	Five	Not specified
		Indoors	Yes	Five	Not specified
	2 (high):	Outdoors	Yes	Five	Not specified
		Indoors	No	N/A	N/A
	3 (very high):	Outdoor public spaces	Yes	Five	Not specified
		Indoors	No	N/A	N/A
5 November 2020	Second national lockdown	All settings	No	N/A	N/A
2 December 2020	Tiers (local COVID-19 alert level): 1 (medium):	Outdoors	Yes	Five	Not specified
		Indoors	Yes	Five	Not specified

	2 (high):	Outdoors	Yes	Five	Not specified
		Indoors	No	N/A	N/A
	3 (very high):	Outdoor public spaces	Yes	Five	Not specified
		Indoors	No	N/A	N/A
19 December 2020	Tier 4	Outdoor public spaces	Yes	One	1m+
5 January 2021	Third national lockdown	All settings	No	N/A	N/A
29 March 2021	Step 1 of roadmap	Outdoor public spaces	Yes	One	1m+
		Indoors	No	N/A	N/A
12 April 2021	Step 2 of roadmap	Outdoors	Yes	Five, or one other household	1m+
		Indoors	No	N/A	N/A
17 May 2021	Step 3 of roadmap	Outdoors	Yes	Twenty-nine	1m+
		Indoors	Yes	Five, or one other household	None
19 July 2021	Step 4 of roadmap	All settings	Yes	No limit	None

Protective behaviours are only effective at preventing transmission of infection if people adhere to them. One way of encouraging uptake is to legally enforce behaviours, and to limit people's opportunity to socialise (e.g. by closing hospitality venues). In England, legal restrictions on social mixing were in place between 27 March 2020 and 19 July 2021.^{5,6} Since then, emphasis has been placed on individuals understanding and managing their own risk.⁷

A range of factors – socio-demographic, contextual, and psychological – may affect whether people adopt protective behaviours. Research suggests that women, older people, those with chronic illnesses, people who perceived measures to be more effective, people who perceived COVID-19 to be a more severe illness, and those who thought that others were also adhering to measures were more likely to adopt physical distancing behaviours.⁸⁻¹¹ A study investigating close contacts during the pandemic found that people who reported more contacts were less likely to think that COVID-19 would be a serious illness for them, were more likely to agree that they were likely to catch COVID-19, and were more concerned that they might spread COVID-19 to others.⁴ These studies investigated factors associated with individual dimensions of social mixing, for example the number of times people had met up with friends or family socially, whether they came into close contact with others, or self-reported adherence to Government guidelines. A detailed understanding of how patterns of social mixing changed under different restrictions over the course of the pandemic is missing. Furthermore, most studies investigated mixing at the start of the pandemic (May 2020), with one study analysing data collected up to December 2020,¹¹ and another analysing data up to

March 2021.⁴ At the time of writing, there were no available data investigating social mixing after the release of all legal restrictions in the UK on 19 July 2021.

Since the start of the COVID-19 outbreak, we have been working with the English Department of Health and Social Care to track behaviours that affect SARS-CoV-2 transmission. Using this dataset and elsewhere in the literature, reporting has so far focused on individual behaviours and associated factors. However, this survey has detailed information on participants' latest reported social mixing (including setting, whether they maintained distance from others, how many other households they mixed with, how many people from other households were present), all of which influence transmission risk. We used these data to:

1. develop a composite measure for risky social mixing based on most recent social mixing, taking into account setting, close contact, number of households, and number of people from other households;
2. describe change over time in the percentage of people engaging in risky social mixing;
3. identify who is most likely to engage in risky social mixing, and whether psychological factors are associated with risky social mixing.

Methods

Design

A series of cross-sectional nationally representative surveys have been carried out by BMG Research since January 2020 on behalf of the English Department of Health and Social Care. We analysed these data as part of the COVID-19 Rapid Survey of Adherence to Interventions and Responses (CORSAIR).¹² For this study, we used data collected between 14 September 2020 and 10 August 2021 (waves 28 to 55).

Participants

Participants were recruited from two specialist research panel providers, Respondi (n=50,000) and Savanta (n=31,500) and were eligible for the study if they were aged 16 years or over and lived in the UK (n≈2,000 per wave). Quotas based on age and gender (combined) were applied to ensure the sample was broadly representative of the UK population. After having completed the survey, participants were unable to take part in the following three waves of data collection. Participants were reimbursed in points which could be redeemed in

cash, gift vouchers or charitable donations (up to 70p per survey). For this study, only participants living in England were selected, as restrictions differed between the four nations of the UK (n≈1,700 per wave).

Study materials

Risky social mixing

All participants were asked “the number of times [they had] been out of [their] home in the last seven days ... to meet up with friends and / or family that [they didn’t] live with”. From 1 June 2021 (wave 51), the wording of this question was slightly changed, to ask participants “how many times [they had] done each of the following activities in the past seven days...met up with friends and / or family that [they didn’t] live with”.

Participants who indicated they had been out at least once were asked a series of follow-up questions about “the last occasion [they] met up with friends and / or family they [didn’t] live with”. Questions asked whether the last occasion participants met up with friends or family occurred indoors or outdoors (“setting”), whether they stayed at least 2m apart (“close contact”), the number of other households present (“total number of households”), and the number of people from outside their household (“number of people from other households”). Full survey items are shown in Table 2.

Table 2. Coding of variables to compute risky social mixing variable.

Variable	Question text	Response options	Risk level
Setting (indoors / outdoors)	And still thinking about only the last occasion you met up with friends and/or family, were you indoors or outdoors? <i>[People in wave 44 were asked a slightly different version of this question. Therefore, we have excluded them from analyses.]</i>	Exclusively outdoors	Lowest (“exclusively outdoors”)
		Mostly outdoors	Medium (“mostly outdoors”)
		Equally split between indoors and outdoors	Highest (“indoors”)
		Mostly indoors	Highest (“indoors”)
Close contact	Again, thinking about the last occasion you met with friends and/or family that you don’t live with, did people stay at least 2m apart?	Exclusively indoors	Highest (“indoors”)
		Yes, at all times	Lowest (“distanced”)
		Yes, most of the time	Lowest (“distanced”)
		Yes, some of the time	Highest (“not distanced”)
Total number of households	The last time you met with friends and/ or family that you don’t live with, how many households (not people)	No – not at all	Highest (“not distanced”)
		Scale	Question + 1 (to include own household)

	did those people come from? Don't include your own household in this number.		Lowest ("2") Highest ("3+")
Number of people from other households	And still thinking about the last time you met friends and/or family that you don't live with, how many people from outside your household were there?	Scale	Lowest ("≤2") Highest ("≥3")

Socio-demographic characteristics

Participants reported their age, gender, employment status, socio-economic grade, highest educational or professional qualification, ethnicity, relationship status, how many people lived in their household, their first language, whether there was a dependent child in the household, and whether they or a household member had a chronic illness. Participants were also asked for their full postcode, from which geographical region and indices of multiple deprivation were determined.¹³

Participants were asked if they thought they had previously, or currently, had COVID-19. We recoded answers into a binary variable ("I've definitely had it, and had it confirmed by a test" and "I think I've probably had it", vs "I don't know whether I've had it or not", "I think I've probably not had it", and "I've definitely not had it").

Financial hardship was measured by asking participants to what extent in the past seven days they had been struggling to make ends meet, skipping meals they would usually have, and were finding their current living situation difficult (Cronbach's $\alpha=.79$).

Contextual and psychological factors

Participants were asked "the number of times [they had] been out of [their] home in the last seven days ... to go out to work". On 1 June 2021 (wave 51), the wording of this question was slightly changed, to ask participants "how many times [they had] done each of the following activities in the past seven days ... left the house to go out to work (number of days)".

Worry about COVID-19 was measured by asking participants "overall, how worried [they were] about coronavirus" on a five-point scale from "extremely worried" to "not at all worried". Perceived risk of COVID-19 was measured by asking participants "to what extent [they thought] coronavirus [posed] a risk to" people in the UK and themselves personally on a five-point scale from "major risk" to "no risk at all".

We asked participants to what extent they agreed that COVID-19 would be a serious illness for them, they would worry about what others would think of them if they tested positive for COVID-19, someone could spread COVID-19 to other people even if they did not have

symptoms yet, their personal behaviour had an impact on how COVID-19 spreads, and they thought the risks of COVID-19 were being exaggerated on a five-point scale from “strongly agree” to “strongly disagree”.

Participants also indicated the extent to which they thought information from the UK Government about COVID-19 a) could be trusted, and b) was biased or one-sided on a five-point scale from “strongly agree” to “strongly disagree”.

Ethics

This work was conducted as a service evaluation of the Department of Health and Social Care’s public communications campaign and, following advice from King’s College London Research Ethics Committee, was exempt from requiring ethical approval.

Power

A sample size of 1,700 allows a 95% confidence interval of about plus or minus 2% for the prevalence estimate for a survey item with a prevalence of 50%.

Analysis

We used information about participants’ latest instance of social mixing to compute a measure of “risky social mixing” via consensus agreement. Participants who reported that they had not been out to meet friends or family that they did not live with were assigned to the “negligible risk” category. For participants who reported having been out to meet friends or family from another household, we combined information about setting (indoors / outdoors), whether they came into close contact with others, the total number of households, and how many people from other households were present to assign them a risk category (lowest / medium / highest risk). First we created dichotomous or trichotomous variables for each factor (Table 1). Variables were then combined to give a risk rating (Figure 1).

Number of meetings in last week	0	1+																							
Setting		Exclusively outdoors								Mostly outdoors								Indoors							
Close contact		Distanced				Not distanced				Distanced				Not distanced				Distanced				Not distanced			
Total number of households		2		3+		2		3+		2		3+		2		3+		2		3+		2		3+	
Number of people from other households		≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3	≤2	≥3
RISK	Negligible	Low	Low	Low	Low	Low	Low	Med	Med	Low	Med	Med	Med	Med	Med	High	High	Med	High	High	High	High	High	High	High

Figure 1. Categorisation of risk ratings

To describe change in risky social mixing over time, we computed risky social mixing for each survey wave, presenting results graphically.

We investigated associations with highest risk social mixing at different time points within the pandemic. We selected slices of data (two or three survey waves) that were collected at six different time points in the pandemic, choosing times when different restrictions were in place. Time points were: 1) rule of six indoors and outdoors (data collected 14 to 30 September 2020), 2) second national lockdown (data collected 9 to 25 November 2020), 3) third national lockdown (data collected 11 January to 14 February 2021), 4) rule of six outdoors, no indoor mixing (data collected 19 April to 5 May 2021), 5) rule of six indoors, up to 30 people outdoors (data collected 1 to 16 June 2021) and 6) no legal restrictions on social mixing (data collected 26 July to 10 August 2021).

We investigated associations between highest risk social mixing and:

1. socio-demographic characteristics (survey wave, region, gender, age [raw and quadratic], presence of a dependent child in the household, having a chronic illness oneself, having a household member who has chronic illness, employment status, socio-economic grade, index of multiple deprivation, highest educational or professional qualification, ethnicity, first language, living alone, relationship status, having had COVID-19 before, and financial hardship) and
2. contextual and psychological characteristics (having been out to work in the last week, worry about COVID-19, perceived risk of COVID-19 [to self and people in the UK], perceived severity of COVID-19, worry about what others would think if you tested positive for COVID-19, agreeing that someone can spread COVID-19 even if asymptomatic, thinking that your personal behaviour has an impact on the spread of COVID-19, thinking that the risks of COVID-19 are exaggerated, agreeing that information from the Government about COVID-19 can be trusted, and is biased or one-sided)

We used multivariable logistic regressions adjusting for all characteristics.

Multiple analyses were run on individual outcomes ($n=12$), therefore we applied a Bonferroni correction ($p \leq .004$).

Results

Participants

Descriptions of risky social mixing are based on 47,933 responses (53.8% female, n=25,772; mean age 48.5 years, SD=17.3, range 16 to 93 years; 82.7% white British, n=39,643; 6.5% white other, n=3,119; 2.4% mixed, n=1,131; 5.0% Asian / Asian British, n=2,413; 2.3% Black / Black British, n=1,097; 0.5% Arab / other, n=246; 0.6% prefer not to say, n=284).

Responses within each of our time slices are from separate individuals. However, respondents may appear in more than one time slice. We estimate the proportion of these individuals is low, but the way the data was collected, to protect respondent anonymity, does not allow us to know an exact number.

Participants in different time slices did not vary significantly by key socio-demographic characteristics (Table 3). Where differences were statistically significant, values only differed minimally (by 4.1% or less). The only exception was the increasing percentage of people who reported that they thought they had had COVID-19 in later time slices. This is congruent with the second wave of infections over winter 2020/2021.

Table 3. Participant socio-demographic characteristics.

		Rule of six indoors and outdoors (total n=3423), % (n)	Second national lockdown (total n=5223), % (n)	Third national lockdown (total n=5116), % (n)	Rule of six outdoors, no indoor mixing (total n=3298), % (n)	Rule of six indoors, up to 30 people outdoors (total n=3367), % (n)	No restrictions on social mixing (total n=3438), % (n)	p-value
Region	East Midlands	8.4 (289)	9.4 (491)	9.1 (468)	9.3 (308)	9.1 (307)	8.8 (303)	.85
	East of England	10.5 (358)	11.7 (610)	12.0 (613)	12.2 (403)	11.4 (383)	10.8 (372)	
	London	14.6 (501)	14.1 (736)	14.0 (714)	13.3 (440)	14.2 (478)	14.2 (489)	
	North East	5.1 (173)	5.8 (302)	5.2 (266)	5.2 (172)	5.3 (177)	5.1 (175)	
	North West	13.6 (466)	13.1 (683)	12.9 (658)	13.2 (436)	12.6 (425)	14.2 (488)	
	South East	15.1 (517)	15.4 (802)	16.0 (819)	15.1 (497)	15.9 (535)	15.1 (518)	
	South West	10.2 (349)	10.0 (522)	10.4 (531)	9.9 (328)	10.4 (350)	10.8 (371)	
	West Midlands	11.2 (382)	10.3 (539)	9.8 (499)	10.8 (357)	10.3 (348)	10.5 (362)	
	Yorkshire and The Humber	11.3 (388)	10.3 (538)	10.7 (548)	10.8 (357)	10.8 (364)	10.5 (360)	
Gender	Male	45.8 (1563)	46.7 (2434)	47.4 (2419)	46.8 (1538)	45.8 (1536)	46.8 (1605)	.66
	Female	54.2 (1852)	53.3 (2774)	52.6 (2682)	53.2 (1751)	54.2 (1816)	53.2 (1828)	
Age	Mean, SD	M=48.0, SD=16.9	M=48.6, SD=17.1	M=48.8, SD=17.5	M=47.6, SD=16.9	M=48.5, SD=17.3	M=49.4, SD=17.3	<.001*
Dependent child in household	None	65.8 (2253)	68.4 (3574)	67.9 (3473)	65.6 (2164)	66.9 (2254)	67.8 (2332)	.03
	Child present	34.2 (1170)	31.6 (1649)	32.1 (1643)	34.4 (1134)	33.1 (1113)	32.2 (1106)	
Chronic illness (self)	No	70.1 (2356)	71.1 (3628)	72.3 (3626)	72.1 (2310)	71.6 (2359)	70.7 (2369)	.26
	Yes	29.9 (1003)	28.9 (1474)	27.7 (1391)	27.9 (892)	28.4 (935)	29.3 (984)	
Household member has chronic illness	No	83.9 (2817)	83.7 (4268)	83.7 (4199)	84.6 (2708)	84.6 (2787)	84.7 (2839)	.62
	Yes	16.1 (542)	16.3 (834)	16.3 (818)	15.4 (494)	15.4 (507)	15.3 (514)	
Employment status	Not working	44.4 (1500)	45.0 (2314)	44.5 (2248)	42.5 (1379)	45.1 (1499)	44.7 (1518)	.27
	Working	55.6 (1880)	55.0 (2830)	55.5 (2807)	57.5 (1867)	54.9 (1824)	55.3 (1876)	
Socio-economic grade‡	ABC1	71.3 (2386)	70.7 (3618)	71.9 (3599)	70.6 (2279)	72.3 (2383)	70.8 (2377)	.46
	C2DE	28.7 (960)	29.3 (1497)	28.1 (1408)	29.4 (951)	27.7 (912)	29.2 (982)	
Index of multiple deprivation	1 st (least) to 4 th quartile (most deprived), mean, SD	M=2.61, SD=1.1	M=2.62, SD=1.1	M=2.56, SD=1.1	M=2.64, SD=1.09	M=2.61, SD=1.1	M=2.61, SD=1.11	.03
Highest educational or professional qualification	Less than degree	67.5 (2311)	65.4 (3417)	65.6 (3357)	66.5 (2192)	67.1 (2259)	66.7 (2292)	.28
	Degree or higher	32.5 (1112)	34.6 (1806)	34.4 (1759)	33.5 (1106)	32.9 (1108)	33.3 (1146)	
Ethnicity	White British	84.7 (2883)	83.5 (4330)	84.1 (4284)	81.2 (2658)	81.8 (2742)	84.6 (2890)	<.001*
	White other	6.5 (221)	6.9 (360)	6.7 (339)	7.4 (242)	6.0 (202)	5.5 (189)	
	Black and minority ethnicity	8.8 (299)	9.6 (498)	9.2 (471)	11.4 (374)	12.1 (407)	9.9 (337)	
First language	Not English	8.0 (274)	8.7 (457)	8.5 (437)	9.5 (314)	8.8 (295)	7.2 (248)	.02
	English	92.0 (3149)	91.3 (4766)	91.5 (4679)	90.5 (2984)	91.2 (3072)	92.8 (3190)	
Living alone	Not living alone	81.1 (2775)	80.2 (4190)	80.4 (4113)	80.3 (2648)	79.4 (2672)	77.0 (2647)	<.001*
	Living alone	18.9 (648)	19.8 (1033)	19.6 (1003)	19.7 (650)	20.6 (695)	23.0 (791)	
Relationship status	Not partnered	39.2 (1323)	38.7 (1995)	38.8 (1969)	39.3 (1283)	40.0 (1332)	40.4 (1372)	.60
	Partnered	60.8 (2053)	61.3 (3161)	61.2 (3104)	60.7 (1984)	60.0 (1996)	59.6 (2028)	
Ever had COVID-19	Think not	84.6 (2895)	85.5 (4464)	83.6 (4278)	82.3 (2714)	82.8 (2788)	79.8 (2745)	<.001*
	Think yes	15.4 (528)	14.5 (759)	16.4 (838)	17.7 (584)	17.2 (579)	20.2 (693)	
Financial hardship	Range 3 (least) to 15 (most), mean, SD	N=3312, M=7.9, SD=3.0	N=5009, M=7.9, SD=3.0	N=4898, M=7.9, SD=2.9	N=3239, M=7.6, SD=3.1	N=3311, M=7.5, SD=3.1	N=3376, M=7.4, SD=3.2	<.001*

* $p \leq .004$

Social mixing

Patterns of risky social mixing changed over time, largely in line with restrictions on social mixing in place at the time of data collection (Figure 2).

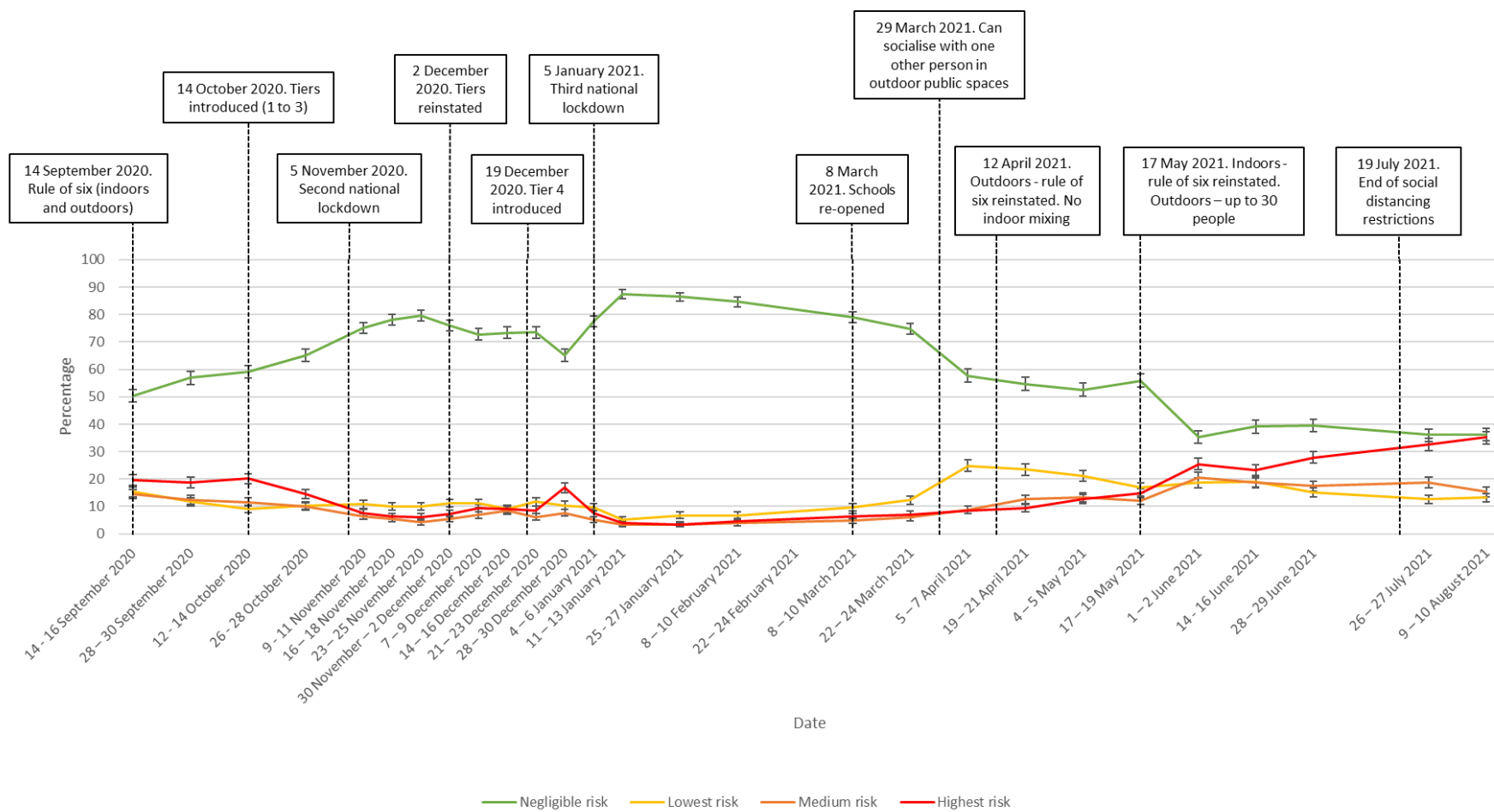


Figure 2. Risky social mixing over time.

There was a large influence of time on engagement in highest risk social mixing (Table 4).

Table 4. Percentage of people engaging in risky social mixing at different time points in the pandemic.

	Rule of six indoors and outdoors (total n=3423), % (n)		Second national lockdown (total n=5223), % (n)		Third national lockdown (total n=5116), % (n)		Rule of six outdoors, no indoor mixing (total n=3298), % (n)		Rule of six indoors, up to 30 people outdoors (total n=3367), % (n)		No restrictions on social mixing (total n=3438), % (n)		p-value
	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	
Negligible risk	53.6 (51.9 to 55.3)	1835	77.6 (76.5 to 78.8)	4055	86.1 (85.2 to 87.1)	4407	53.6 (51.9 to 55.3)	1769	37.2 (35.6 to 38.9)	1254	36.2 (34.6 to 37.8)	1244	<.001
Lowest risk	13.6 (12.4 to 14.7)	465	10.3 (9.5 to 11.1)	538	6.2 (5.6 to 6.9)	318	22.3 (20.9 to 23.8)	737	18.8 (17.5 to 20.1)	632	12.9 (11.8 to 14.0)	443	<.001
Medium risk	13.6 (12.4 to 14.7)	464	5.3 (4.7 to 6.0)	279	3.6 (3.1 to 4.1)	186	13.0 (11.8 to 14.1)	428	19.6 (18.3 to 20.9)	660	17.1 (15.8 to 18.3)	587	<.001
Highest risk	19.3 (17.9 to 20.6)	659	6.7 (6 to 7.4)	351	4.0 (3.5 to 4.5)	205	11.0 (10.0 to 12.1)	364	24.4 (22.9 to 25.8)	821	33.9 (32.3 to 35.4)	1164	<.001

At all timepoints, engaging in highest risk social mixing was associated with being less worried about COVID-19, perceiving a smaller risk of COVID-19 to oneself and people in the UK, lower perceived severity of COVID-19 to oneself, and thinking the risks of COVID-19 are being exaggerated (Tables 5 and 6).

Table 5. Socio-demographic characteristics associated with engaging in highest risk social mixing at different time points in the pandemic.

Attribute	Level	Rule of six indoors and outdoors		Second national lockdown		Third national lockdown		Rule of six outdoors, no indoor mixing		Rule of six indoors, up to 30 people outdoors		No legal restrictions	
		aOR for engaging in highest risk social mixing (95% CI) †	p	aOR for engaging in highest risk social mixing (95% CI) †	p	aOR for engaging in highest risk social mixing (95% CI) †	p	aOR for engaging in highest risk social mixing (95% CI) †	p	aOR for engaging in highest risk social mixing (95% CI) †	p	aOR for engaging in highest risk social mixing (95% CI) †	p
Survey wave in timepoint	Wave 1	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Wave 2	0.93 (0.77 to 1.11)	.40	0.85 (0.64 to 1.12)	.25	0.82 (0.55 to 1.21)	.32	1.57 (1.24 to 1.99)	<.001*	0.87 (0.73 to 1.02)	.09	1.14 (0.98 to 1.32)	.09
	Wave 3	-	-	0.81 (0.61 to 1.08)	.16	1.25 (0.88 to 1.79)	.22	-	-	-	-	-	-
	Overall	-	-	$\chi^2(2)=2.3$	.32	$\chi^2(2)=5.0$	.08	-	-	-	-	-	-
Region	East Midlands	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	East of England	0.93 (0.62 to 1.40)	.74	1.50 (0.91 to 2.47)	.11	0.98 (0.48 to 2.02)	.96	1.20 (0.71 to 2.02)	.50	1.09 (0.76 to 1.57)	.64	1.26 (0.90 to 1.77)	.17
	London	0.90 (0.61 to 1.34)	.61	1.02 (0.62 to 1.70)	.93	1.07 (0.55 to 2.07)	.84	1.11 (0.66 to 1.85)	.70	0.99 (0.69 to 1.44)	.97	1.14 (0.82 to 1.58)	.44
	North East	0.91 (0.55 to 1.49)	.70	0.79 (0.39 to 1.60)	.52	1.11 (0.47 to 2.63)	.81	1.28 (0.68 to 2.40)	.45	1.64 (1.07 to 2.52)	.02	1.14 (0.75 to 1.72)	.54
	North West	0.59 (0.39 to 0.89)	.01	0.85 (0.49 to 1.45)	.54	1.34 (0.69 to 2.61)	.39	0.80 (0.47 to 1.38)	.43	0.89 (0.62 to 1.29)	.55	0.94 (0.68 to 1.30)	.72
	South East	0.87 (0.60 to 1.28)	.49	1.14 (0.69 to 1.88)	.60	1.00 (0.51 to 1.97)	1.00	1.62 (1.00 to 2.64)	.05	0.89 (0.63 to 1.26)	.51	1.13 (0.82 to 1.55)	.46
	South West	1.22 (0.82 to 1.82)	.32	1.03 (0.59 to 1.79)	.92	0.65 (0.28 to 1.47)	.30	1.26 (0.74 to 2.16)	.40	1.06 (0.73 to 1.54)	.74	0.98 (0.70 to 1.38)	.92
	West Midlands	0.89 (0.60 to 1.33)	.57	1.29 (0.77 to 2.16)	.33	1.38 (0.70 to 2.74)	.35	1.03 (0.60 to 1.77)	.91	1.22 (0.84 to 1.76)	.30	0.92 (0.66 to 1.30)	.65
	Yorkshire and The Humber	0.94 (0.63 to 1.40)	.76	1.15 (0.68 to 1.95)	.60	1.43 (0.73 to 2.79)	.30	1.28 (0.76 to 2.17)	.36	1.18 (0.82 to 1.71)	.37	1.13 (0.80 to 1.59)	.49
	Overall	$\chi^2(8)=14.1$	.08	$\chi^2(8)=8.6$	.38	$\chi^2(8)=6.6$	.58	$\chi^2(8)=10.8$	.21	$\chi^2(8)=13.7$	.09	$\chi^2(8)=6.9$	.54
Gender	Male	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Female	1.09 (0.90 to 1.31)	.38	0.80 (0.63 to 1.01)	.06	0.58 (0.42 to 0.79)	.001*	0.85 (0.67 to 1.07)	.17	1.11 (0.93 to 1.31)	.24	1.17 (1.00 to 1.36)	.05
Age (per decade)	Raw age	0.89 (0.83 to 0.95)	.001*	0.88 (0.80 to 0.96)	.004*	0.84 (0.75 to 0.94)	.003*	0.86 (0.79 to 0.94)	.001*	0.92 (0.86 to 0.98)	.01	0.93 (0.87 to 0.99)	.01
Age: quadratic (age-mean) ²	-	1.0004 (1.0000 to 1.0007)	.03	1.0004 (0.9999 to 1.0008)	.09	1.0005 (0.9999 to 1.0010)	.09	1.0008 (1.0003 to 1.0012)	<.001*	1.0002 (0.9999 to 1.0005)	.29	1.0001 (0.9998 to 1.0003)	.63
Dependent child in household	None	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Child present	1.08 (0.87 to 1.35)	.49	1.16 (0.87 to 1.55)	.30	1.21 (0.83 to 1.77)	.31	1.16 (0.88 to 1.55)	.30	1.02 (0.83 to 1.26)	.85	0.94 (0.77 to 1.13)	.50
Chronic illness (self)	No	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Yes	0.8 (0.65 to 1.00)	.05	0.78 (0.58 to 1.04)	.09	1.33 (0.94 to 1.89)	.11	0.88 (0.66 to 1.16)	.37	1.04 (0.86 to 1.26)	.70	0.84 (0.70 to 1.00)	.05
Household member has chronic illness	No	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Yes	0.86 (0.66 to 1.12)	.27	1.12 (0.81 to 1.56)	.50	0.96 (0.61 to 1.53)	.87	0.81 (0.56 to 1.16)	.24	0.98 (0.77 to 1.25)	.89	0.88 (0.70 to 1.09)	.23
Employment status	Not working	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Working	0.96 (0.77 to 1.19)	.70	0.76 (0.58 to 1.00)	.05	1.21 (0.83 to 1.76)	.32	0.90 (0.68 to 1.19)	.45	0.90 (0.74 to 1.10)	.31	0.81 (0.67 to 0.97)	.03
Socio-economic grade†	ABC1	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	C2DE	1.16 (0.94 to 1.43)	.16	1.02 (0.78 to 1.33)	.90	1.17 (0.83 to 1.65)	.38	1.22 (0.94 to 1.58)	.14	0.92 (0.75 to 1.12)	.39	1.03 (0.87 to 1.23)	.71
Index of multiple deprivation	1 st (least) to 4 th quartile (most deprived)	1.04 (0.95 to 1.13)	.43	1.06 (0.95 to 1.19)	.30	1.07 (0.92 to 1.24)	.37	1.14 (1.02 to 1.29)	.02	0.95 (0.88 to 1.03)	.20	0.93 (0.87 to 1.01)	.07
Highest educational or professional qualification	Less than degree	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Degree or higher	0.98 (0.79 to 1.20)	.83	0.81 (0.62 to 1.05)	.11	1.10 (0.79 to 1.54)	.57	0.95 (0.73 to 1.24)	.70	0.99 (0.82 to 1.20)	.92	0.86 (0.73 to 1.02)	.09

Ethnicity	White British	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	White other	1.15 (0.74 to 1.81)	.53	1.71 (1.06 to 2.78)	.03	1.09 (0.56 to 2.12)	.80	1.43 (0.87 to 2.35)	.15	1.04 (0.68 to 1.60)	.85	1.44 (0.96 to 2.14)	.08
	Black and minority ethnicity	0.82 (0.57 to 1.20)	.31	1.60 (1.09 to 2.35)	.02	1.34 (0.82 to 2.21)	.24	1.18 (0.80 to 1.73)	.40	0.82 (0.61 to 1.12)	.22	0.97 (0.73 to 1.31)	.86
	Overall	$\chi^2(2)=1.9$	.39	$\chi^2(2)=8.0$	.02	$\chi^2(2)=1.4$	.50	$\chi^2(2)=2.2$	.33	$\chi^2(2)=1.8$	.41	$\chi^2(2)=3.5$	.18
First language	Not English	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	English	1.23 (0.79 to 1.91)	.36	1.23 (0.77 to 1.96)	.38	0.76 (0.43 to 1.33)	.33	1.18 (0.74 to 1.89)	.48	1.09 (0.75 to 1.60)	.66	2.15 (1.44 to 3.19)	<.001*
Living alone	Not living alone	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Living alone	1.16 (0.86 to 1.57)	.34	1.59 (1.10 to 2.30)	.01	1.96 (1.27 to 3.01)	.002*	1.61 (1.11 to 2.33)	.01	1.14 (0.86 to 1.50)	.36	1.23 (0.96 to 1.57)	.10
Relationship status	Not partnered	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Partnered	0.83 (0.65 to 1.05)	.12	0.82 (0.60 to 1.12)	.21	0.49 (0.33 to 0.72)	<.001*	0.87 (0.64 to 1.17)	.36	1.12 (0.89 to 1.40)	.33	1.14 (0.93 to 1.41)	.21
Ever had COVID-19	Think not	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Think yes	1.08 (0.84 to 1.40)	.55	0.95 (0.68 to 1.33)	.75	1.50 (1.05 to 2.16)	.03	1.20 (0.90 to 1.60)	.22	1.06 (0.84 to 1.32)	.64	1.01 (0.82 to 1.23)	.94
Financial hardship	Range 3 (least to 15 (most))	0.94 (0.91 to 0.98)	.001*	1.01 (0.97 to 1.06)	.54	0.98 (0.93 to 1.04)	.52	0.99 (0.95 to 1.03)	.66	0.95 (0.92 to 0.98)	.001*	0.94 (0.91 to 0.96)	<.001*

† Adjusting for wave, region, gender, age (raw and quadratic), presence of a dependent child in the household, having a chronic illness oneself, having a household member who has chronic illness, employment status, socio-economic grade, index of multiple deprivation, highest educational or professional qualification, ethnicity, first language, living alone, relationship status, having had COVID-19 before, and financial hardship.

* $p \leq .004$

Table 6. Contextual and psychological factors associated with engaging in highest risk social mixing at different time points in the pandemic.

Attribute	Level	Rule of six indoors and outdoors		Second national lockdown		Third national lockdown		Rule of six outdoors, no indoor mixing		Rule of six indoors, up to 30 people outdoors		No legal restrictions	
		aOR for engaging in highest risk social mixing (95% CI) †	<i>p</i>	aOR for engaging in highest risk social mixing (95% CI) †	<i>p</i>	aOR for engaging in highest risk social mixing (95% CI) †	<i>p</i>	aOR for engaging in highest risk social mixing (95% CI) †	<i>p</i>	aOR for engaging in highest risk social mixing (95% CI) †	<i>p</i>	aOR for engaging in highest risk social mixing (95% CI) †	<i>p</i>
Been out to work in last week	No	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-	Ref	-
	Yes	1.34 (1.06 to 1.68)	.01	1.14 (0.86 to 1.52)	.37	1.76 (1.23 to 2.53)	.002*	1.74 (1.30 to 2.34)	<.001*	1.23 (1.00 to 1.51)	.06	1.20 (0.99 to 1.45)	.06
Worry about COVID-19	5-point scale (1=not at all worried to 5=extremely worried)	0.75 (0.69 to 0.82)	<.001*	0.65 (0.58 to 0.72)	<.001*	0.65 (0.57 to 0.75)	<.001*	0.67 (0.60 to 0.75)	<.001*	0.71 (0.65 to 0.77)	<.001*	0.76 (0.71 to 0.81)	<.001*
Perceived risk of COVID-19 to self	5-point scale (1=no risk at all to 5=major risk)	0.78 (0.71 to 0.85)	<.001*	0.65 (0.58 to 0.73)	<.001*	0.74 (0.64 to 0.85)	<.001*	0.72 (0.64 to 0.81)	<.001*	0.68 (0.62 to 0.74)	<.001*	0.81 (0.75 to 0.87)	<.001*
Perceived risk of COVID-19 to people in the UK	5-point scale (1=no risk at all to 5=major risk)	0.81 (0.74 to 0.89)	<.001*	0.62 (0.55 to 0.70)	<.001*	0.60 (0.52 to 0.70)	<.001*	0.71 (0.63 to 0.80)	<.001*	0.78 (0.71 to 0.85)	<.001*	0.82 (0.76 to 0.89)	<.001*
Coronavirus would be a serious illness for me	5-point scale (1=strongly disagree to 5=strongly agree)	0.75 (0.69 to 0.82)	<.001*	0.61 (0.54 to 0.68)	<.001*	0.71 (0.61 to 0.82)	<.001*	0.65 (0.58 to 0.73)	<.001*	0.73 (0.67 to 0.79)	<.001*	0.79 (0.73 to 0.85)	<.001*
I would worry about what others would think of me if I tested positive for coronavirus	5-point scale (1=strongly disagree to 5=strongly agree)	0.87 (0.81 to 0.95)	.001*	0.85 (0.76 to 0.94)	.002*	0.90 (0.79 to 1.03)	.12	0.91 (0.82 to 1.00)	.06	0.88 (0.82 to 0.95)	.001*	0.81 (0.76 to 0.87)	<.001*
Someone could spread coronavirus to other people, even if they do not have symptoms yet	5-point scale (1=strongly disagree to 5=strongly agree)	0.92 (0.82 to 1.03)	.13	0.72 (0.63 to 0.82)	<.001*	0.68 (0.57 to 0.80)	<.001*	0.75 (0.66 to 0.86)	<.001*	0.86 (0.78 to 0.95)	.004*	0.97 (0.89 to 1.06)	.52
My personal behaviour has an impact on how coronavirus spreads	5-point scale (1=strongly disagree to 5=strongly agree)	0.83 (0.76 to 0.91)	<.001*	0.74 (0.67 to 0.82)	<.001*	0.74 (0.64 to 0.85)	<.001*	0.70 (0.63 to 0.78)	<.001*	0.88 (0.81 to 0.95)	.001*	0.93 (0.87 to 1.00)	.05
I think the risks of coronavirus are being exaggerated	5-point scale (1=strongly disagree to 5=strongly agree)	1.19 (1.10 to 1.28)	<.001*	1.47 (1.33 to 1.62)	<.001*	1.42 (1.25 to 1.61)	<.001*	1.37 (1.24 to 1.51)	<.001*	1.18 (1.09 to 1.27)	<.001*	1.14 (1.06 to 1.22)	<.001*
Information from the Government about coronavirus can be trusted	5-point scale (1=strongly disagree to 5=strongly agree)	0.84 (0.77 to 0.90)	<.001*	0.79 (0.71 to 0.88)	<.001*	0.84 (0.74 to 0.96)	.009	0.79 (0.71 to 0.87)	<.001*	0.85 (0.79 to 0.92)	<.001*	0.86 (0.80 to 0.91)	<.001*

Information from the Government about coronavirus is biased or one-sided	5-point scale (1=strongly disagree to 5=strongly agree)	1.03 (0.95 to 1.12)	.51	1.05 (0.94 to 1.18)	.37	1.17 (1.02 to 1.35)	.03	1.08 (0.97 to 1.20)	.17	1.07 (0.99 to 1.15)	.10	0.98 (0.92 to 1.05)	.60
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† Adjusting for wave, region, gender, age (raw and quadratic), presence of a dependent child in the household, having a chronic illness oneself, having a household member who has chronic illness, employment status, socio-economic grade, index of multiple deprivation, highest educational or professional qualification, ethnicity, first language, living alone, relationship status, having had COVID-19 before, and financial hardship.

* $p \leq .004$

At most timepoints (four or five out of six), engaging in highest risk social mixing was associated with younger age, not agreeing that you would worry about what others would think of you if you tested positive for COVID-19, not agreeing that someone can spread COVID-19 even if asymptomatic, not agreeing that your personal behaviour has an impact on how COVID-19 spreads, and not agreeing that information from the Government about COVID-19 can be trusted (Tables 5 and 6).

Lower financial hardship was associated with engaging in highest risk social mixing at three timepoints (Table 5), while having been out to work was associated with engaging in highest risk social mixing at two time points (Table 6).

In the third national lockdown, engaging in highest risk social mixing was associated with being male, living alone, and not having a partner (Table 5). When the rule of six was in place outdoors but there was no indoor mixing, later survey wave was associated with engaging in highest risk social mixing (Table 5). When there were no legal restrictions on social mixing, speaking English as your first language was associated with engaging in highest risk social mixing (Table 5).

Discussion

We computed a composite measure of social mixing associated with a higher risk of SARS-CoV-2 transmission, taking into account setting, physical distancing, number of households present, and number of people from other households present. We described how people's social mixing patterns varied between September 2020 and August 2021. This measure of social mixing shows clear variation in line with UK Government guidance in place at the time of data collection, including low rates of any social mixing during the third national lockdown, an increase in lower risk socialising (outdoors) between April and May 2021, and an increase in highest risk socialising (indoors) following the opening of indoor hospitality. Our analyses replicate findings on contact patterns during the pandemic,⁴ and extend them by suggesting that changes occurred not only in the number, but also in the nature, of social interactions.

Psychological factors were consistently associated with engaging in highest risk social mixing. Similar to other studies, we found that highest risk social mixing was associated with lower perceived risk of COVID-19,¹⁴ being less worried about COVID-19,^{15,16} and lower perceived severity of COVID-19.^{4,8} As in other pandemics, believing that the risks of the virus were being exaggerated was associated with not engaging in protective behaviours.¹⁷

While strong and consistent associations between worry about, perceived risk and perceived severity of illness suggest that increasing worry and risk may result in increased protective behaviours, messaging designed to increase worry and perception of risk should only be contemplated when perceived risk is disproportionately low and in tandem with messaging highlighting the effectiveness of protective behaviours.¹⁸

Lower knowledge that SARS-CoV-2 can spread even when asymptomatic was consistently associated with engaging in highest risk social mixing. Other studies have also shown that people with lower knowledge of transmission are less likely to intend to adhere to the test, trace, and isolate system.¹⁹ People who agreed that their personal behaviour had an impact on how COVID-19 spreads were less likely to engage in highest risk social mixing. This is in line with other evidence on internal health locus of control and uptake of health behaviours,^{20,21} but not with another study which found that internal locus of control was associated with decreased self-reported adherence to Government guidance on social mixing.¹¹ This study measured self-reported adherence, which necessarily depends on participants' knowledge of guidance; evidence suggests that knowledge is sub-optimal.^{8,22} Increasing knowledge about SARS-CoV-2 transmission and emphasising that an individual's behaviour can affect the spread of the virus may encourage uptake of protective behaviours such as lower risk social mixing. Associations between highest risk social mixing and disagreeing that information about COVID-19 from the Government can be trusted suggest that messaging about such issues may be better received if it is communicated by sources other than the Government, such as the National Health Service (NHS) or public health agencies.

Highest risk social mixing was associated with socio-demographic characteristics, namely younger age, having been out to work, and lower financial hardship. These findings may in part reflect the fact that younger people have higher rates of social contacts,^{23,24} and that people who attend work have on average twice the number of social contacts than those working from home.²⁵ It also follows that, if people have been in close contact with others in the workplace, they may be more comfortable and perceive less risk in socialising with them outside of work. People in greater financial hardship may be less likely to be able to afford costs associated with frequent higher risk socialising (e.g. transport to and from meeting points, eating or drinking at hospitality venues).

After the removal of all legal restrictions on socialising on 19 July 2021, the UK Government moved to a system where individuals were expected to understand and manage their own

risk, rather than follow rules.⁷ However, risk perception is complex,²⁶ and evidence suggests that people have difficulty interpreting their own risk in different situations.²⁷ While messaging may encourage people to engage in less risky social mixing, our evidence and that from elsewhere suggests that the biggest driver of mixing behaviour is the restrictions in place at the time.²⁸⁻³⁰ If they are needed again, obtaining large reductions in mixing as a result of communication alone may prove challenging.

Strengths of this study include that it gives a nuanced insight into social mixing behaviour over the course of the pandemic, spanning different restrictions, including the removal of all legal restrictions on social mixing. Limitations include: 1) the use of an online sample, whose views and behaviours may not be representative of the wider population, although associations within the data should remain valid.³¹ 2) Surveys were cross-sectional, therefore we cannot imply causation. 3) We asked participants for details about the most recent time they met with people from another household to minimise recall bias. As surveys were conducted at the start of the week (usually Monday to Tuesday or Wednesday), people's most recent instance of social mixing was likely to have been during the preceding weekend. Socialising patterns during the week may be different. 4) Participants were asked about their behaviour in the previous week. In some cases, this may have overlapped with a change in restrictions. 5) Patterns of social mixing may not be as significant predictors of COVID-19 risk as other aspects of a person's life, such as their work environment, commuting and interactions with social and healthcare.

This study outlines patterns of social mixing between September 2020 and August 2021 using a composite measure drawing together information about factors influencing transmission risk (setting, distancing, and number of other households and individuals from other households present). Mixing behaviour varied according to the restrictions in place at the time. Messages targeting psychological factors, such as increasing knowledge about SARS-CoV-2 transmission and that an individual's behaviour can impact the spread of the virus, may promote lower risk social mixing. However, should Government deem it necessary to significantly reduce risky social mixing in a short space of time, it is likely that a reimposition of restrictions may be necessary.

Data Availability Statement

The data are owned by the UK's Department of Health and Social Care, so no additional data are available from the authors.

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Author contributions

All authors conceptualised the study. LS completed analyses and wrote the first draft of the manuscript. HWWP, RA, NTF, SM and GJR contributed to subsequent drafts. All authors approved the submitted manuscript and are personally accountable for their own contributions.

Funding sources

This work was funded by the National Institute for Health Research (NIHR) Health Services and Delivery Research programme. Surveys were commissioned and funded by Department of Health and Social Care (DHSC), with the authors providing advice on the question design and selection. LS, RA and GJR are supported by the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Emergency Preparedness and Response, a partnership between the UK Health Security Agency, King's College London and the University of East Anglia. RA is also supported by the NIHR HPRU in Behavioural Science and Evaluation, a partnership between the UK Health Security Agency and the University of Bristol. HWWP has received funding from Public Health England and NHS England. NTF is part funded by a grant from the UK Ministry of Defence. The views expressed are those of the authors and not necessarily those of the NIHR, UK Health Security Agency, the Department of Health and Social Care or the Ministry of Defence.

Competing Interests Statement

All authors had financial support from NIHR for the submitted work; RA is an employee of the UK Health Security Agency; HWWP has received additional salary support from Public Health England and NHS England; HWWP receives consultancy fees to his employer from Ipsos MORI and has a PhD student who works at and has fees paid by Astra Zeneca; NTF is a participant of an independent group advising NHS Digital on the release of patient data. All authors are participants of the UK's Scientific Advisory Group for Emergencies or its subgroups.

Table and figure legends

Table 1. Restrictions on social mixing in England during the pandemic (March 2020-July 2021)

Table 2. Coding of variables to compute risky social mixing variable.

Table 3. Participant socio-demographic characteristics.

Table 4. Percentage of people engaging in risky social mixing at different time points in the pandemic.

Table 5. Socio-demographic characteristics associated with engaging in highest risk social mixing at different time points in the pandemic.

Table 6. Contextual and psychological factors associated with engaging in highest risk social mixing at different time points in the pandemic.

Figure 1. Categorisation of risk ratings

Figure 2. Risky social mixing over time.