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Availability of primary care and avoidable attendance at English emergency departments: A regression analysis

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Highlights

We use data on 10M attendances English Emergency Departments

9.3% were avoidable by the official NHS and 21.8% our new definition

Attendances by deprived patients were less likely to be avoidable

Attendances when practices had extended hours were less likely to be avoidable

Abstract

Attendances at emergency departments (EDs) by patients who could have been treated in primary care increase waiting times and costs in EDs and may reduce quality of care. This study examines whether the probability that a patient's ED attendance is avoidable is associated with their characteristics and the quality, staffing, and availability of their general practice, particularly its extended hours provision. We estimate ED attendance level linear probability and logistic regressions using data on 10.16M attendances at 144 major EDs by patients aged 16 or over from 6,668 English practices. We use two definitions of avoidable ED attendance: the NHS definition (non-urgent) and a new wider definition (clinically inappropriate).

9.3% of attendances were avoidable according to the NHS definition and 21.8% with our definition. The probability of avoidable attendance was lower for older, female patients, those living in more socioeconomically deprived or sparsely populated areas, or those closer to their practice than to the ED attended. Attendances from practices where a higher proportion of patients get same-day GP appointments, or were aware of early morning extended hours, were less likely to be avoidable. The probability that an ED attendance was clinically inappropriate was about 0.5% smaller during weekends or evenings when the practice had extended hours but was not associated with the overall provision of extended hours by the practice.

Keywords. Avoidable ED attendances. Primary care availability. Extended hours. General Practice. England

Background

Greater demand in emergency departments (ED) can lead to longer waits, worse outcomes, and increased cost (Morley et al. 2018, Pearce et al, 2023). Some ED attendances are avoidable in the sense that the patient could have been treated elsewhere, particularly in primary care. International estimates of avoidable ED attendance range from 10% to 90% of attendances, because of differences in definitions of avoidable attendance and in healthcare systems (Berchet and Nader, 2016; Carret et al., 2009; Durand, et al., 2011; Pines et al., 20111). In OECD countries avoidable attendances are generally around 20-30%. For the English National Health Service (NHS) estimates of avoidable ED attendance range from 10% (NHS Digital, 2020) to 43% (Thompson et al., 2013).

Primary care is the most obvious substitute for avoidable ED attendances and studies suggest that improving the availability of primary care will reduce both overall and avoidable attendances (Flores-Mateo et al., 2012; Bruni et al., 2016). English NHS policy has encouraged general practices to extend their opening hours (NHS England, 2016).

Whittaker et al. (2016) found that Manchester patients in 56 general practices which introduced 7-day extended access had, relative to those in 469 practices which did not, a 26.4% reduction in ED visits for minor problems and a small but statistically insignificant reduction in total ED visits. Dolton and Pathania (2016) also used difference in difference methods and found that four practices in Central London which introduced 7-day extended access had, compared to 30 control practices, reduced ED attendances by 9.9% overall and 17.9% at weekends, with the largest reduction in moderately severe cases but with no effect for minor severity cases.

Three studies used cross-sectional practice level data for all English practices to examine the associations between ED attendances and general practice availability. Cowling et al. (2013) found that in 2010/11 practices with a higher proportion of patients reporting that they could see a GP within two days, had fewer avoidable visits per patient. Parkinson et al. (2020) used 2015/16 practice level data and found that avoidable ED attendances were weakly negatively associated with practice clinical quality and easy phone access but not with being able to get same day appointments. Cowling et al. (2018) used pooled cross-section data for three years

(2011/12 -2013/14) and found that lower practice level rates of ED attendances and emergency admissions were associated with increased patient satisfaction with making practice appointments, though there were small or inconsistent associations with satisfaction with opening hours and overall satisfaction.

We contribute to the literature in a number of ways. We use data on 10.16M adult attendances at English EDs in 2018/19 to estimate *attendance* level, rather than practice level, multiple regression models of the association of practice availability, including detailed data on practice extended hours provision, with whether the ED attendance was avoidable.

We use two definitions of avoidable attendance: the official NHS Digital definition (NHS Digital, 2020) used to track *non-urgent* attendances and a new wider definition based on whether the attendance is *clinically inappropriate*. Our analysis is based on the last financial year (2018/19) for which there is detailed practice level national data on extended access. We have data on individual attendances at EDs, including the time of attendance, and can thus allow for the substantial variation by time of day and day of week in the probability that an attendance is avoidable. We examine whether the probability of an ED attendance being avoidable is associated with measures of *overall availability* of the attender's practice, including extended opening hours. We are also able to use information on the time of each attendance to examine whether the probability that an ED attendance is avoidable is associated with *specific availability*: whether the attender's practice had extended opening hours at the time of their ED attendance, thus potentially providing more detailed policy guidance on the timing of extended opening hours.

Institutional background

Primary medical care in the English NHS is provided by general practices, almost all owned and run by partnerships of General Practitioners (GPs). In 2018/19 there were 7,271 practices with an average list of 8,113 patients and 4.11 full-time equivalent GPs (NHS Digital, 2024). General practices manage chronic conditions and are the first point of contact for nonemergency medical care. Primary care is free at the point of use, apart from a small charge for around 10% of prescriptions. Practices are paid by a mix of need-weighted capitation, lump sums, items of service fees, and quality incentives. Practices are reimbursed for premises costs but must cover all other expenses, including non-partner salaried GPs, nurses, and support staff.

General practice core hours are 08.00 to 18.30 on Monday to Friday. The NHS encouraged practices to provide extended access outside these hours on weekdays, Saturdays, and Sundays. Extended access could be provided by the practice itself or in collaboration with a group of local practices. Practices were paid an average of \pounds 10,831 in 2018/19 (around 0.09% of their total NHS payment) for providing extended hours (NHS Digital, 2019a).

Methods

Definition of avoidable ED attendances

An international literature review (Durand et al., 2011) found 51 methods for categorising the 'appropriateness' of ED attendances. Definitions differed in the time of categorisation (prospectively versus retrospectively), health professional perspective (ED physician vs ED triage nurse vs GP), and in the specific criteria used to categorise ED attendances.

We use two definitions of an avoidable ED attendance (**Table 1**). NHS Digital defines an ED attendance as *non-urgent* if it is a "first attendance with some recorded treatments or investigations all of which may have reasonably been provided in a non-emergency care setting, followed by discharge home or to GP care" (NHS Digital, 2020). The definition was proposed by Mason et al. (2017) and O'Keeffe, et al. (2018) but its implementation by NHS Digital differs in that arrival by ambulance is deemed sufficient to classify the attendance as urgent. NHS Digital has not reported non-urgent ED attendance since 2018/19.

Our second definition is new: "an attendance is clinically *inappropriate* when the process of care, and resources required for adequate assessment and timely treatment, including diagnostic investigations and clinician time, could with reasonable expectation have been competently delivered in a non-emergency care setting." The definition was developed by one of the authors (TJ) with a background in emergency medicine in consultation with two primary care physicians. In common with the NHS Digital definition, an attender arriving in an ambulance (Arrival domain) or an attendance ending with hospital admission (Disposal domain) would not be classified as avoidable, regardless of information recorded in other domains. Unlike the NHS Digital definition, the use of lab-based blood testing (Investigation domain) would not be sufficient to classify an attendance as not avoidable, since this is available in non-emergency settings, including primary care. Also in contrast with the NHS Digital definition, any diagnosis in 12 diagnosis fields, such as lacerations or septicaemia would be sufficient to classify an attendance as appropriate. (Supplementary materials **Table S1**.)

Data

ED attendances. We use data from Accident and Emergency Hospital Episode Statistics (HES A&E) on each attendance by individual pseudonymised patients aged at least 16 at all Type 1 EDs (24-hour consultant-led with full resuscitation facilities) in England from April 2018 to March 2019. HES A&E records care provided, arrival date and time, attender's age, gender, ethnicity, general practice, and small area of residence (Lower Super Output Area (LSOA), mean population around 1500). We measure attender socioeconomic deprivation by rescaling the 2015 Index of Multiple Deprivation (IMD) for LSOAs (Ministry of Housing and Local Government, 2015) so that it is bounded between 0 and 1 and higher values indicate *greater* deprivation.

Frequent attenders account for a significant proportion of attendances (Greenfield et al., 2020). Since their unobserved characteristics may affect the probability that their attendances are avoidable, we include an indicator for patients who attended more than five times (Royal College of Emergency Medicine, 2017).

Distance is a key determinant of choice of health care provider (Turnball et al., 2008; Santos, et al., 2017; Murphy et al., 2021). We measure straight line distances from the centroid of the attender's LSOA to their practice and to the ED they attend and use a three category measure of the *difference* in these distances:

- Minimal absolute difference (≤ 0.5 km)
- GP closer than ED (ED > 0.5km further)
- ED closer than GP (practice > 0.5km further)

We also include a sparsity indicator of the rurality of the attender's LSOA (Office for National Statistics, 2016).

Practice characteristics. Practice staffing and quality may influence ED attendance. We measure staffing as the number of full-time equivalent GPs per 1000 patients (NHS Digital, 2024). Clinical quality is the percentage of the maximum number of points achieved for the care of chronic conditions in the Quality and Outcomes Framework (QOF) incentive scheme (NHS Digital, 2019b).

The annual General Practice Patient Survey (GPPS) is sent to a 5% random sample of patients in English general practices and asks for their views on their practice (Ipsos MORI, 2019). We use the percentage of GPPS respondents who report that they are very or fairly satisfied with their care as a measure of patient perceptions of practice quality. We include the practice GPPS response rate to control for survey response bias.

Time slots. ED attendances vary markedly by time of day and day of week (O'Keeffe et al. 2018). No specific times were stipulated for extended access hours but practices were expected to offer at least an additional 1.5 hours on weekdays (NHS England, 2018). We assume that extended hours slots on weekdays were contiguous with core hours and were in the morning at weekends. We define 24 slots:

Weekday Core hours: 08.00-18.30 (5 slots)
Weekday AM extended hours: 06.30-08.00 (5 slots)
Weekday PM extended hours: 18.30-20.00 (5 slots)
Weekend extended hours: 09.00-13.00 (2 slots)
Out of hours: Monday-Friday 20.00-06.30 next day, Saturday 13.00-Sunday 09.00, 13.00-Monday 06.30 (7 slots)

Extended hours. We use practice reports of their extended hours provision (NHS England, 2018) to measure extended access provided by the practice and by its practice group.

Exclusions. We exclude observations on attendances by patients under 16, or attending on any Bank Holiday, or at an ED which is more than 50km from their LSOA centroid (patient is likely away from their usual place of residence), or whose practice is more than 20km from their LSOA (patient has likely recently changed practice and their registration has not been updated). Details are in **Supplementary materials Table S3**.

Regression modelling

We estimate attendance level linear and logistic models of the probability that attendance a by patient i from practice p in group g at ED j at time slot t was avoidable (The full specification is described in the online **Supplementary Appendix**.). Explanatories include the characteristics of the patient (age, gender, deprivation, difference in patient-practice and patient-ED distances), patient percentage reporting they are very or fairly satisfied with care, clinical quality, GPs per 1000 patients). We control for the *attendance time slot*, using 23 indicators, with Wednesday core hours as the omitted baseline.

Practice extended hours could affect the probability that an ED attendance is avoidable in two ways. The first is *general availability*: having extended hours at *some* time slots in the week may affect the probability of an avoidable attendance at *any time* during the week is avoidable because it gives the patient more opportunities to see their GP. We use two measures of general availability: (a) the proportions of GPPS respondents report they can get same day appointments, can get next day appointments, are aware of the practice having extended morning, evening, and Saturday opening hours; (b) eight counts of the number of extended hours slots provided on weekday mornings, weekday evenings, Saturday, and Sunday by the practice and by its group.

The second way in which extended hours could affect the probability of an attendance being avoidable is if it is *in a time slot when the attender's practice or its group has extended hours*. We measure this *specific availability* with eight indicators of whether the attendance was in an

extended hours slot on a weekday morning, weekday evening, Saturday, and Sunday provided by the practice or by its group.

Models include ED fixed effects to control for unobserved characteristics of the ED attended (coding practices, triaging rules, staffing, distances to other non-GP providers) which may affect the probability that an attendance is avoidable.

Results

Descriptive statistics

Attendances were twice as likely (21.75%) to be clinically inappropriate as non-urgent (9.29%) (**Table S2**). Raw agreement between the definitions was 0.85 and Cohen's kappa was 0.44 which is conventionally taken to indicate moderate agreement (McHugh, 2012).

Table 2 reports summary statistics. Just over half of attendances (53%) were by female patients and 76% by those of white ethnicity. Frequent attenders (\geq five attendances in the year) were 4.5% of attenders but had 16% of attendances. Since there are 6,668 GP practices and 144 EDs, many more (81%) attendances were by patients who lived closer to their practice than to the ED attended. Attenders' GP practices averaged 96% of QOF points and had high levels of patient satisfaction.

GPPS respondents had little knowledge of the general availability of their practice outside normal hours: only small percentages were aware of extended hours. However, nearly a third said that they were able to book same day appointments.

Practice reports of extended hours suggest that there was relatively little provision in the early morning extended hours slot by practices or by their group. There was greater provision in the weekday evening slots, particularly by practice groups (2.84 out of 5 slots) rather than by the practice itself (1.18 out of 5 slots). At weekends 27% of practices had an extended hours slot on Saturdays but only 5% on Sundays. Group provision was 62% on Saturdays and 54% on Sundays.

Figure S1 (**Supplementary Materials**) plots the average weekly pattern by hour and day of the week of the *total volume* of ED attendances and *the percentages of attendances classified as avoidable* by the two definitions. Early morning hours have the smallest number of attendances and the lowest proportion of avoidable attendances. Conversely, the number of attendances and the proportions which are avoidable are greatest on weekdays between 8am and 18.00 and around noon on Saturdays and Sundays. This suggests that ED attendances by individuals whose ED attendance would be classified as avoidable are more sensitive to the time of day than ED attendances by those who would not be classified as avoidable.

The distribution of attendances across aggregated time slots shows 44.3% of attendances were during core practice hours, 40.9% outside both normal and extended hours and 14.7% during weekday evenings or mornings or weekend hours when extended access *might* have been available (**Supplementary materials Table S4**). Nearly two fifths of these (596,899) had no provision of extended hours by the attender's practice or group of practices.

Figure 1 shows attendances during periods when there *could* have been extended hours provision were more likely to be inappropriate than those in core practice hours or out of hours of both core practice and extended opening.

Attendances in extended hours periods when extended hours *were* provided by the attender's practice or its group had a *higher* probability of being avoidable (10.48% or 25.10%) than attendances when extended hours could have been provided but were not (9.44% or 24.20%). However, these unconditional comparisons do not control for differences in the characteristics of attendances or practices.

Regression results

Table 3 has results from linear and logistic models of the probability that an attendance was avoidable. We report average marginal effects of a unit change in explanatory variables. (Full results for both estimation methods are reported in **Supplementary Material Table S5**.)

The patterns of signs and statistical significance are very similar for the LPM and logistic specifications and both definitions of avoidable attendance. In all but one case statistically

significant marginal effects are around twice as large in absolute value for inappropriate attendance than for non-urgent attendance (as we show in a note in the **Supplementary Material**, this is likely because the mean probability that attendances are inappropriate is about twice as large as the mean probability that attendances are non-urgent).

We concentrate on the LPM model of inappropriate ED attendance results. The marginal effects of attendance time slots from the LPM model (**Figure 1**) are very similar to the unconditional pattern in **Figure S1**. Out of hours attendances are *less* likely to be non-urgent/inappropriate, suggesting that patients are less willing to wait for treatment when they have more serious symptoms.

The LPM model suggests that a 10-year increase in age is associated with a 4% reduction in the probability of inappropriate attendance. *Figure S2* (in *Supplementary Material*) shows that the proportion of inappropriate attendances against age declines linearly with age. Attendances by women are slightly (0.5%) less likely to be avoidable (gender is the only statistically significant explanatory variable where the estimated coefficient is absolutely larger for non-urgent than for inappropriate attendance.) White ethnicity is associated with a small (2%) reduction in the probability of inappropriate attendance.

Attendances by frequent attenders are less likely to be inappropriate, suggesting that they attend ED frequently because they have worse health. Moore et al. (2009) also found that attendances by frequent attenders at a London ED are less likely to be avoidable. We find, (as in McHale et al., 2013) that attendances from patients in more deprived areas are *less* likely to be avoidable. Geography and distance are strongly associated with avoidable attendance: attendances by those who live closer to their practice than to the ED are less likely to be inappropriate, as are attendances by those who live in sparsely populated areas.

Four of the eight measures of *specific* availability (ED attendance when extended hours are provided) are associated with reductions in the probability that the attendance was clinically inappropriate, though not in the narrower definition of being non-urgent. None of the eight measures of *general* availability based on patient reports of practice extended hours are associated with reductions in the probability of avoidable attendance. The general availability of the attender's practice as measured by patient reports of whether they are aware of extended

hours is also not consistently associated with the probability that attendance was avoidable. However, a more direct patient reported measure of general availability - the proportion of patients who say that they can get same day appointments at the practice - is associated with a reduction in the probability of avoidable attendance.

It is possible that extended hours provision also indirectly affects avoidable attendance by increasing the proportion of practice patient GPPS respondents reporting that they are aware of extended opening hours or are able to book same-day or next-day appointments. However, dropping all the variables based on GPPS reports of general practice availability did not lead to material changes in magnitudes or statistical significance of the coefficients on specific or general availability measures based on extended hours slots (**Supplementary Material Table S4**).

QOF points are associated with a reduced probability of *non-urgent* attendance but the association is very weak: increasing the percentage of QOF points attained by 10% would reduce the probability by 0.0013%. There is no statistically significant association with the probability of *clinically inappropriate* attendance. Patient satisfaction with care and the number of GPs per patient were also not associated with avoidable attendance.

Discussion

People attend EDs with a variety of conditions some of which could be managed elsewhere. We used linear and logistic multiple regression models with data on over 10M ED attendances in 2018/19 to examine the association of the characteristics of individual attendees and their general practice with the probability that the ED attendance was avoidable – better suited to management elsewhere – according to an official NHS Digital definition and to a new wider definition incorporating richer clinical information on the attendance. Estimated associations were smaller and less often statistically significant with the NHS Digital definition which classifies markedly fewer attendances as avoidable (9.3%) compared with our new definition (21.8%). The pattern of results was however similar across definitions of avoidable attendance, and across estimation methods.

On average practices (either directly or as part of a local group) provided extended access for one weekday morning, and three weekday evenings. Nearly 90% provided extended hours on

Saturdays and nearly 60% on Sundays. Specific availability – the attender's practice or group had extended hours *at the time of their attendance* – was associated with a reduction in probability that the attendance was avoidable only for attendances on weekday evenings and at weekends. There was no evidence that greater general availability – having more extended hours at *some* time slots in the week – was associated with a reduced probability that an ED attendance at *any* time during the week was avoidable.

Compared with practice characteristics, individual characteristics were more strongly associated with the probability that an attendance is avoidable. Greater deprivation is strongly associated with a smaller probability of the attendance being avoidable. This is likely because poor health is strongly associated with deprivation (Marmot, 2020). The probability is also markedly smaller for older patients who are more likely to have worse underlying health, and for those living in sparse surroundings who will face greater difficulties in accessing EDs and be willing to do so only for serious health concerns.

2018-19 was the last year for which data on extended hours provision were available. The COVID-19 pandemic might be expected to change patterns of attendance. However, despite temporary reductions in lockdown phases, by March 2022 non-urgent attendances had exceeded expected growth trends (Huo, et al., 2023) particularly among younger patients, making this a continuing target for policy intervention.

Future work could extend the analysis in a number of ways. We used a single cross-section of data and so the analysis is potentially vulnerable to unobserved practice level factors correlated with extended hours provision and with the probability of avoidable ED attendance by patients. Richer cross-section data on practice GPs, other practice staff, and patients could reduce such endogeneity concerns. Using primary care appointment level data, or linked datasets such as CPRD, it would be possible to understand the impact of introducing extended hours provision on avoidable/inappropriate attendance, also taking into account information from patient's past primary care consultations and fuller primary care history. A full assessment of whether and how extended hours provision affects the level of avoidable attendance by changing general and specific practice availability would be much more complex since it would also require a difference-in-differences approach to understand the effect of providing extended hours provision on the rate of ED attendance at each time slot. Alternatively, and more simply, it

would be possible, to extend the models in Parkinson et al (2020), to examine how the rate of avoidable ED attendance from a practice across all time slots varied with practice extended hours provision.

The recently introduced Emergency Care Data Set (ECDS) also offers opportunities for further work. It replaced the HES A&E data set and provides more detailed information on patients' diagnoses (using SNOMED codes) and chief complaints, enabling the development of new definitions of avoidable ED attendance, perhaps based on Ambulatory Care Sensitive Conditions (Parkinson et al., 2022) or the candidacy framework (Fisher et al. 2024) to improve the management of non-urgent cases in EDs.

Conclusion

Our analysis indicates that while primary care extended hours were not overall significantly associated with a reduction in avoidable ED attendances, specifically extended hours availability during weekday evenings and weekends were linked to a small reduction. Moreover, high-quality practice management such as same-day GP appointments seems to reduce the probability that an ED attendance is avoidable.

Extended access policy was replaced in October 2022 by Enhanced Access, shifting responsibility from individual GP practices to Primary Care Networks (PCNs). PCNs are required to ensure equitable access to appointments across all network practices, enabling any patient within the network to book extended hours appointments, irrespective of their registered practice. Richer data will help understand the factors driving avoidable ED attendance to support this policy aim of empowering people to access person-appropriate and clinical need-appropriate care.

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Tables and Figures

Table 1.	Definitions	of avoidable	ED attendances

Domain	Non-Urgent (NHS Digital)	Clinically inappropriate
ARRIVAL MODE	<i>Not</i> : Ambulance	Not: Ambulance
ATTENDANCE		Not: Planned ED follow-up
CATEGORY		
DISPOSAL	Any of:	Not: Admitted, Died in department,
	Discharged – with follow up	Referred to ED clinic, or to fracture
	treatment to be provided by GP;	clinic
	Discharged – no follow up	
	required; Left department before	
	treatment; Missing.	
REFERRAL		<i>Not</i> referred by: General medical
SOURCE		practitioner, Emergency services,
		General dental practitioner
DIAGNOSIS		<i>None</i> of: 12 fields including a
		diagnosis of e.g. Laceration,
		Septicaemia, Burns and scalds.
INVESTIGATION	Any of: 'None' recorded; field	<i>None</i> of: 10 fields including an
	blank; Urinalysis; Pregnancy	investigation of e.g. CT, Cardiac
	test; Dental investigation, or	enzymes, Arterial/capillary blood
	Missing	gas.
TREATMENT	Any of: 'None' recorded; field	<i>None</i> of: 52 fields with treatment
	blank; Guidance/advice only;	including e.g. Resuscitation/CPR,
	Prescriptions; Recording vital	Dressing major wound/burn,
	signs: Dental treatment: Missing.	Primary sutures.

Note. Definitions based on domains and fields in HES A&E. For non-urgent attendance every domain specification is *necessary*. For clinically inappropriate satisfaction of *any* domain specification is *sufficient* for the attendance to be avoidable. See Supplementary Table S1 for the full details of the domain specifications, including full diagnoses, investigations and treatments sufficient to deem not clinically inappropriate.

	Mean	SD	Min	Max
Attendance characteristics				
Clinically inappropriate attendance	0.217	0.413	0	1
Non-urgent attendance	0.093	0.290	0	1
Age	51.36	22.44	16.00	113.00
Female	0.531	0.499	0	1
White ethnicity	0.759	0.427	0	1
Attendance by frequent attendee	0.159	0.365	0	1
Deprivation (rescaled IMD rank)	0.571	0.286	0.011	1.000
Location with sparse surroundings	0.007	0.083	0	1
GP at least 0.5km closer than ED	0.813	0.390	0	1
ED at least 0.5km closer than GP	0.042	0.200	0	1
Specific availability: ED attendance in extended hour				
During practice extended hours weekday AM	0.004	0.061	0	1
During practice extended hours weekday PM	0.017	0.128	0	1
During practice extended hours Saturday	0.011	0.103	0	1
During practice extended hours Sunday	0.002	0.044	0	1
During group extended hours slot weekday AM	0.001	0.031	0	1
During group extended hours slot weekday PM	0.034	0.182	0	1
During group extended hours slot Saturday	0.020	0.140	0	1
During group extended hours slot Sunday	0.019	0.136	0	1
General availability of practice: extended hours				
Practice extended hours slots weekday AM	0.78	1.41	0	5
Practice extended hours slots weekday PM	1.18	1.41	0	5
Practice extended hours slot Saturday	0.27	0.44	0	1
Practice extended hours slot Sunday	0.05	0.22	0	1
Group extended hours slots weekday AM	0.24	1.03	0	5
Group extended hours slots weekday PM	2.84	2.42	0	5
Group extended hours slot Saturday	0.62	0.49	0	1
Group extended hours slot Sunday	0.54	0.50	0	1
General availability of practice: GPPS reports				
Aware of weekday AM extended hours (%)	9.86	9.32	0	63.85
Aware of weekday PM extended hours (%)	12.43	8.66	0	62.60
Aware of Saturday extended hours (%)	8.44	9.68	0	72.36
Able to book same day appointment (%)	32.19	13.87	0	87.32
Able to book next day appointment (%)	11.96	6.48	0	59.00
Practice characteristics				
Very or Fairly Satisfied With Care (%)	84.15	9.66	37.26	100.00

Table 2. Summary statistics: attendance and practice characteristics

QOF Points 2017/18 (% maximum)	96.39	5.46	39.86	100
Full-time equivalent GPs per 1000 patients	0.56	0.26	0	5.51
GPPS Response Rate (%)	36.75	11.03	3.30	64.73

Note: Attenders aged 16 and over. Attendance characteristics and Specific availability of primary care descriptive statistics are at attendance level (sample size of 10,161,346). Specific availability of primary care: ED attendance was in time slot when attender's practice or its group offered extended access. Practice characteristics, including General availability of practice, and descriptive statistics are at GP practice level (sample size of 6,668).

Definition of avoidable attendance:	Inappropriate	Non-urgent	Inappropriate	Non-urgent
Estimation:	LPM	LPM	Logistic	Logistic
Attender characteristics				
Age (years)	-0.00397***	-0.00178***	-0.00412***	-0.00193***
	(-207.18)	(-137.82)	(-372.32)	(-262.41)
Female	-0.00517***	-0.00627***	-0.00588***	-0.00683***
	(-15.47)	(-26.25)	(-17.60)	(-28.49)
White ethnicity	-0.0199***	-0.0111***	-0.0196***	-0.0104***
	(-23.38)	(-23.72)	(-26.66)	(-27.13)
Frequent attender	-0.0619***	-0.0235***	-0.0685***	-0.0263***
	(-91.32)	(-50.97)	(-88.54)	(-49.53)
Deprivation (IMD)	-0.0273***	-0.00956***	-0.0240***	-0.00689***
	(-20.67)	(-12.44)	(-17.81)	(-9.68)
Location with sparse surroundings	-0.0265***	-0.0117***	-0.0506***	-0.0188***
	(-5.89)	(-5.17)	(-7.57)	(-6.64)
GP at least 0.5km closer than ED	-0.0174***	-0.00808***	-0.0177***	-0.00812***
	(-19.22)	(-15.58)	(-20.39)	(-17.04)
ED at least 0.5km closer than GP	0.0127***	0.00729***	0.0115***	0.00631***
	(11.79)	(9.88)	(11.18)	(9.34)
Specific availability: ED attendance in practic	e and group exten	ded hour slot		
Practice Weekday AM	0.00136	0.00290	0.00117	0.00363*
	(0.53)	(1.77)	(0.48)	(2.10)
Practice Weekday PM	-0.00341**	-0.000804	-0.00306*	-0.000761
	(-2.64)	(-0.88)	(-2.51)	(-0.91)
Practice Saturday	-0.00524**	-0.000383	-0.00441**	-0.000631
	(-2.86)	(-0.29)	(-2.70)	(-0.53)
Practice Sunday	0.00242	0.000297	0.000384	-0.000267
	(0.60)	(0.10)	(0.12)	(-0.11)
Group weekday AM	0.00205	0.00467	0.00199	0.00513
Corres Westelsen DM	(0.44)	(1.47)	(0.45)	(1.62)
Group weekday PM	(0.15)	(1.61)	-0.000292	0.000751
Group Saturday	(0.13)	(1.01)	(-0.20)	(0.97)
Gloup Saturday	(2.79)	(0.22)	(3.01)	(0.67)
Group Sunday	(-2.79)	0.000302	(-3.91)	(-0.07)
Group Sunday	(-3, 15)	-0.000302	(-5, 17)	(-1, 21)
Converal availability: practice and aroup exten	(-3.13)	(-0.23)	(-5.17)	(-1.21)
Practice Weekday ΔM	0 00100*	0 0000908	0.00105*	0.000129
	(2 28)	(0 38)	(2 27)	(0.60)
Practice Weekday AM	0.000378	0.000692	0.000327	0.000809
	(0.88)	(0.30)	(0.78)	(0.37)
Practice Saturday	0.00170	0.000929	0.00188	0.00140
There's surfaces	(1.07)	(1.05)	(1.19)	(1.72)
Practice Sunday	-0.00293	-0.000989	-0.00294	-0.00154
·····	(-1.01)	(-0.58)	(-1,06)	(-1.00)
Group Weekday AM	-0.000283	-0.000185	-0.000187	-0.0000792
T	(-0.51)	(-0.62)	(-0.34)	(-0.29)
Group Weekday PM	-0.000412	-0.0000927	-0.000419	-0.000165
1	(-0.67)	(-0.39)	(-0.71)	(-0.74)
Group Saturday	0.00220	-0.000801	0.00153	-0.000281
± •	(0.65)	(-0.57)	(0.46)	(-0.20)

	D 1 1 114	41 4 44	· ·	• • • •		• 1 00 4
Table 3	Probability	that atter	idance is	avoidable	average m	arginal effects
I unic of	1 1 Obability	mai aitei	iuunce 15	a voiuabici	a ver age m	aigmai circes

Group Sunday	0.00200	0.00238*	0.00278	0.00235*
	(0.80)	(2.20)	(1.06)	(2.12)
General availability: GPPS reports				
Aware of weekday AM extended hours (%)	-0.000142*	-0.0000474	-0.000152*	-0.0000576
	(-2.00)	(-1.24)	(-2.14)	(-1.57)
Aware of weekday PM extended hours (%)	0.0000210	-0.0000204	0.0000323	-0.00000242
	(0.27)	(-0.47)	(0.42)	(-0.06)
Aware of Saturday extended hours (%)	0.000133	0.000105*	0.000113	0.0000835*
	(1.70)	(2.41)	(1.48)	(2.12)
Able to book same day appointment (%)	-0.000190***	-0.0000641**	-0.000171***	-0.0000580**
	(-4.44)	(-2.99)	(-4.13)	(-2.83)
Able to book next day appointment (%)	-0.000163	-0.000104*	-0.000128	-0.0000816
	(-1.73)	(-2.07)	(-1.42)	(-1.76)
Practice characteristics				
Very or fairly satisfied with care (%)	-0.000114	-0.0000529	-0.000130	-0.0000591
	(-1.63)	(-1.36)	(-1.91)	(-1.64)
QOF Points 2017-18 (%)	-0.000197	-0.000134*	-0.000182	-0.000101
	(-1.57)	(-2.02)	(-1.62)	(-1.64)
FTE GPs per 1000 patients	-0.00309	-0.000344	-0.00307	0.000132
	(-1.21)	(-0.28)	(-1.22)	(0.11)
GPPS Response Rate (%)	-0.000913***	-0.000605***	-0.000826***	-0.000512***
	(-12.58)	(-14.83)	(-11.72)	(-14.53)

Note. Results from models with ED fixed effects. Observations 10,161,346. Average marginal effects are reported for all specifications. Regressions also include 23 dummy variables for attendance in four time slots on each of five weekdays and two time slots for each of Saturday and Sunday (baseline: Wednesdays core hours). Deprivation: IMD rank rescaled so that *higher* rank indicates *greater* deprivation. Full results are in Online Supplementary Appendix Table S.3. Robust standard errors in parentheses: *** p<0.001, ** p<0.01, * p<0.05.

Figure 1. Marginal effects of attendance time on probability that attendance is inappropriate



Note: Average marginal effects from the Linear Probability Model reported in Table 3 and Online Supplementary Appendix Table S.3. Wednesday Core Hours (08.00-18.30) is omitted time slot.

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Ethical approval:

Not required for analysis of pseudonymised individual data.

Online Supplementary Material

Model specification

Note on linear probability model coefficients

Table S1. Full definition of appropriate attendanceTable S2. Selection of estimation sampleTable S3. Full results for linear and logistic regression modelsTable S4. Results from models without GPPS general availability variables

Figure S1. Probability of avoidable attendance and attender age Figure S2. Marginal effects of attendance time on probability that attendance is nonurgent

Model specification

We estimate linear and logistic models of the probability π_{aipj} that attendance *a* by patient *i* from practice *p* at ED *j* was avoidable. The linear probability model (LPM) specification is $A_{aipj} = \mathbf{x}_{ipj}\mathbf{\beta} + \mathbf{z}_p \mathbf{\gamma} + \mathbf{D}_a^T \mathbf{\delta} + \mathbf{S}_{aip}^{TH} \mathbf{\omega} + \mathbf{S}_{aig}^{TH} \mathbf{\pi} + \mathbf{G}_p^H \mathbf{\lambda} + \mathbf{G}_g^H \mathbf{\theta} + c_j + \varepsilon_{aipj}$

 A_{aipj} is an indicator that the *a*'th attendance by patient *i* in practice *p* at ED *j* was avoidable. \mathbf{x}_{ipj} is a vector of the characteristics of patient *i* registered at practice *p* attending ED *j* (age, gender, deprivation, sparsely populated location, difference in patient-practice and patient-ED distances). z_p is a vector of practice *p* characteristics (% patients reporting they are very or fairly satisfied with care, practice clinical quality, GPs per 1000 patients). We include the practice GPPS response rate in z_p to control for selection bias in responses to the GPPS.

 \mathbf{D}_{a}^{T} is a vector of 23 indicators for the attendance time slot, with Wednesday core hours as the omitted baseline slot. We measure the specific availability of extended hours with two four element vectors \mathbf{S}_{aip}^{TH} , \mathbf{S}_{aig}^{TH} of indicators for whether the attendance was in an extended hours slot on a weekday morning, weekday evening, Saturday, and Sunday provided by the practice or by its group. General availability of extended hours is measured by two four element vectors \mathbf{G}_{p}^{H} and \mathbf{G}_{g}^{H} of the numbers of extended hour slots provided for the aggregated timeslots on: weekday mornings, weekday evenings, Saturdays, and Sundays by the practice and by its group respectively. c_{j} is the ED j fixed effect. We estimate the model with the Stata 18 routine *xtreg fe*. The reported estimated coefficients are the average marginal effects of the explanatories.

The logit specification has the same explanatories as the LPM. We report the average marginal effect of each explanatory evaluated at the mean of the estimated ED fixed effects and the means of the other explanatories. We do not report the log odds as these cannot be sensibly

compared across models with different sets of explanatory variables (Norton and Dowd, 2018). We do not use the Stata 18 fixed effects logit routine (*xtlogit fe*) which conditions out the ED fixed effects, rather than estimating them, and so cannot produce estimates of the average marginal effects from the non-linear logit model. Instead we use the *logit* routine which estimates the ED fixed effects directly. This potentially suffers from the incidental parameter bias which affects estimation of parameters in non-linear functions containing fixed effects (Lancaster, 2000). However, this bias decreases with the number of observations per fixed effect (Greene, 2004) and the minimum number of attendances per ED is 14,000 and the average is 70,565. Hence, we suggest that the incidental parameters problem is not serious for our logit specification. We report robust standard errors clustered on practices for both LPM and logit models.

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Note on linear probability model coefficients¹

This note provides intuition for the estimated LPM coefficients on explanatory variables in Table 5 being generally larger in absolute magnitude when the dependent variable is inappropriate attendance (mean 0.217) rather than non-urgent attendance (mean 0.093). Intuition, not proof, since the note does not consider multiple regressions with more than one explanatory variable.

The estimated coefficient on a single explanatory variable x from an ordinary least squares model of avoidable attendance is

$$\hat{\beta} = \frac{Cov(A, x)}{V(x)}$$

where A is the binary indicator for avoidable attendance with unconditional mean p and x is the explanatory variable which may be binary, discrete, or continuous. The covariance between the binary A and x is

$$Cov(A, x) = E(Ax) - E(A)E(x)$$

= $p\left\{E\left[Ax|A=1\right]\right\} + (1-p)\left\{E\left[Ax|A=0\right]\right\} - pE(x)$
= $p\left\{E\left[x|A=1\right]\right\} + (1-p)\left\{E\left[0x|A=0\right]\right\} - pE(x)$
= $pE\left[x|A=1\right] - pE(x)$

¹ The note is based on Sarwate, D. (2018). Covariance of binary and continuous variable. Stack Exchange. https://stats.stackexchange.com/questions/50817/covariance-of-binary-and-continuous-variable

$$= pE[x|A=1] - p\{pE[x|A=1] + (1-p)E[x|A=0]\}$$

$$= pE[x|A=1] - \{ppE[x|A=1] + p(1-p)E[x|A=0]\}$$

$$= pE[x|A=1] - ppE[x|A=1] - p(1-p)E[x|A=0]$$

$$= p(1-p)E[x|A=1] - p(1-p)E[x|A=0]$$

$$= p(1-p)\{E[x|A=1] - E[x|A=0]\}$$

Hence the absolute magnitude of $\hat{\beta}$ is increasing in p for $p < \frac{1}{2}$ and decreasing for $p > \frac{1}{2}$.

HES Variable	Code	Description	Sufficient for appropriate attendance
AEARRIVALMODE	1	Ambulance	Yes
	2	Other	
	9	Not Known	
AEATTENDCAT	1	First ED attendance	
	2	Follow-up - planned	Yes
	3	Follow-up - unplanned	
	9	Not known	
AEATTENDISP	1	Admitted	Yes
	2	Discharged - GP f/u	
	3	Discharged - no f/u	
	4	Referred A&E clinic	Yes
	5	Referred fracture clinic	Yes
	6	Referred other outpatient	
	7	Transferred to another h/c provider	
	10	Died in dept	Yes
	11	Referred to other h/c professional	
	12	Left dept before treatment	
	13	Left having refused treatment	
	14	Other	
	99	Not known	
AEREFSOURCE	0	General medical practitioner	Yes
	1	Self-referral	
	2	Local authority social services	
	3	Emergency services	Yes
	4	Work	
	5	Educational establishment	
	6	Police	
	7	Health care provider	
	8	Other	
	92	General dental practitioner	Yes
	93	Community dental service	
	99	Unknown	

 Table S1. HES A&E indicators for sufficient for ED attendance to be appropriate

DIAG2_NN	01	Laceration	Yes
2-character	02	Contusion/abrasion	
diagnosis	03	Soft tissue inflammation	
	04	Head Injury	Yes
	05	Dislocation/fracture/joint	Vaa
	05	injury/amputation	Ies
	06	Sprain/ligament injury	
	07	Muscle/tendon injury	
	08	Nerve injury	Yes
	09	Vascular injury	Yes
	10	Burns and scalds	Yes
	11	Electric shock	Yes
	12	Foreign body	Yes
	13	Bites/stings	
	14	Poisoning	Yes
	15	Near drowning	Yes
	16	Visceral injury	Yes
	17	Infectious disease	
	18	Local infection	
	19	Septicaemia	Yes
	20	Cardiac conditions	
	21	Cerebro-vascular conditions	
	22	Other vascular	
	23	Haematological	
	24	Central Nervous System Exc. Stroke	
	25	Respiratory	
	26	Gastrointestinal	
	27	Urological (inc. cystitis)	
	28	Obstetric	
	29	Gynaecological	
	30	Diabetes and other endocrinological	
	31	Dermatological	
	32	Allergy (inc. anaphylaxis)	
	33	Facio-maxillary conditions	
	34	Ear nose and throat	
	35	Psychiatric	
	36	Ophthalmological	
	37	Social problems	
	38	Not classifiable	
	39	Nothing abnormal detected	
INVEST_N	01	X-Ray - plain film	
Investigation	02	ECG	Yes
	03	Haematology	
	04	Cross-match	Yes

1	o 7		
	05	Biochemistry	
	06	Urinalysis	
	07	Bacteriology	
	08	Histology	
	09	CT (retired 2006)	Yes
	10	Ultrasound	Yes
	11	MRI	Yes
	12	CT ex. Genito-urinary contrast	Yes
	13	GU contrast CT	Yes
	14	Clotting	
	15	Immunology	
	16	Cardiac enzymes	Yes
	17	Arterial/capillary blood gas	Yes
	18	Toxicology	Yes
	19	Blood culture	
	20	Serology	
	21	Pregnancy test	
	21	Dental investigation	
	22	Pafraction orthoptic tests visual fields	
	23 24	None	
	2 4 00	Other	
ΤΡΕΔΤ3 Ν	011	Dragging minor wound/burn/ovo	
2 sharester	012	Dressing major wound/burn	Vac
5-character	012	Diessing inajor wound/buin	Vas
treatment	02	Bandage/support	Vac
	031	Primary sutures	I es
	032	Secondary/complex suture	res
	033	Removal of sutures/clips	
	041	Wound closure - steristrips	
	042	Wound closure - glue	
	043	Wound closure - other eg. Clips	Yes
	051	Plaster of Paris - application	Yes
	052	Plaster of Paris - removal	
	06	Splint	Yes
	08	Removal of foreign body	Yes
		Physiotherapy - strapping, US	
	091	treatment, short wave diathermy,	
		manipulation	
	092	Physio - gait re-education, falls	
	101	prevention	X 7
	101	Manipulation of upper limb fracture	Yes
	102	Manipulation of lower limb fracture	Yes
	103	Manipulation of dislocation	Yes
	11	Incision and drainage	Yes
	12	Intravenous cannula	Yes

13	Central Line	Yes
14	Lavage/emesis/charcoal/eye irrigation	Yes
15	Intubation etc.	Yes
16	Chest drain	Yes
17	Urinary catheter/suprapubic	Yes
181	Defibrillation	Yes
182	External pacing	Yes
19	Resuscitation/CPR	Yes
20	Minor surgery	Yes
21	Observation/ECG, pulse oximetry/head injury/trends	Yes
221	Guidance only - written	
222	Guidance only - verbal	
231	Anaesthesia - general	Yes
232	Anaesthesia - local	Yes
233	Anaesthesia - regional block	Yes
234	Anaesthesia - entonox	Yes
235	Anaesthesia - sedation	Yes
236	Anaesthesia - other	Yes
241	Tetanus - immune	
242	Tetanus - tetanus toxoid course	
243	Tetanus - tetanus toxoid booster	
244	Tetanus - human immunoglobulin	Yes
245	Tetanus - combined tetanus/diphtheria course	
246	Tetanus - combined tetanus/diphtheria	
25	booster	Vac
23	Nebuliser/spacer	res
27	Other	Vaa
281	Parenteral thrombolysis - streptokinase	res
282	plasminogen activator	Yes
291	Other parenteral drugs - stat/bolus	Yes
292	Other parenteral drugs - infusion	Yes
30	Recording vital signs	
31	Burns review	
32	Recall/x-ray review	Yes
33	Fracture review	
34	Wound cleaning	Yes
35	Dressing/wound review	
36	Sling/collar&cuff/broad arm sling	Yes
37	Epistaxis control	Yes
38	Nasal airway	Yes
39	Oral airway	Yes
40	Supplemental oxygen	Yes

41	CPAP/nasal IPPV/BVM	Yes
42	Arterial line	Yes
43	Infusion fluids	Yes
44	Blood product transfusion	Yes
45	Pericardiocentesis	Yes
46	Lumbar puncture	Yes
47	Joint aspiration	Yes
48	Minor plastic procedure	Yes
49	Active rewarming of hypothermic	Yes
.,	patient	
50	Cooling - control of body temperature	Yes
511	Medication administered - oral	
512	Medication administered - intra-	
513	Medication administered - subcutaneous	
514	Medication administered - per-rectum	
515	Medication administered - sublingual	
516	Medication administered - intra-nasal	
517	Medication administered - eve drops	
518	Medication administered - ear drops	
5 10	Medication administered - topical skin	
519	cream	
521	Occupational therapy functional	
321	assessment	
522	Occupational therapy activities of daily	
522	living equipment provision	
53	Loan of walking aid (crutches)	Yes
54	Social worker intervention	
551	Eye - orthoptic exercises	
552	Eye - laser of retina/iris/retrobulbar	
	capsule	
553	Eye - retrobulbar injection	
554	Eye - epilation of lashes	
555	Eye - subconjunctival injection	
56	Dental treatment	
57	Prescription/medicines prepared to take	
00	away	
フフ	INUIIC	

Note: ED attendance is *inappropriate* if and only if it *does not* have any of the characteristics shown as sufficient for attendance not to be avoidable.

Table S2. Correlation of avoidable attendance definitions

Clinically inappropriate	Total	
--------------------------	-------	--

		Ν	Y		
Non-Urgent	Ν	7,818,330	1,398,871	9,217,201	90.71%
	Y	133,005	811,140	944,145	9.29%
Total		7,951,335	2,210,011	10,161,346	
		78.25%	21.75%		

Agreement: 84.92%. Expected agreement: 73.00%. Kappa: 0.4416, SE: 0.0003

Table S3 – Selection of estimation sample

Criteria	Exclusion	Observations
All ED attendances		22,367,847
Sequential exclusions		
Age under 16 years	4,735,461	
Invalid English GP practice code*	640,037	
Not Type 1 ED	4,700,017	
Duplicates	4,058	
Atypical days**	229,221	
Non-English LSOAs	124,399	
Do not have GP practice information	562,113	
AED > 50 km	372,288	
GP practice > 20km	838,907	
Total exclusions		12,206,501
Estimation sample		10,161,346

* Attendances from attendees whose GP practice code is, according to the NHS Digital HES A&E dictionary, No Registered General Practitioner Practice, General Practitioner Practice Code not applicable or General Practitioner Practice Code not known

**Atypical days: Bank Holidays, junior doctor strikes.

	Attendance time slot					
	(1)	(2)	(3)	(4)	(5)	(6)
	Extended	Extended	All	Core	Out of	Total
	hours: no	hours: with	extended	hours	hours	
	provision	some provision	hours		-	
Attendances	596,899	901,141	1,498,040	4,504,710	4,158,596	10,161,346
% total attendances	5.87%	8.87%	14.74%	44.33%	40.93%	100.00%
% Non-urgent	9.44%	10.48%	10.08%	9.40%	8.90%	9.30%
% Inappropriate	24.20%	25.10%	24.75%	22.20%	20.20%	21.70%

 Table S4. Summary statistics: avoidable attendances by time slot

Definition of avoidable attendance:	Inappropriate	Non-urgent	Inappropriate	Non-urgent
Estimation:	LPM	LPM	Logistic	Logistic
Attender characteristics				
Age (years)	-0.00397***	-0.00178***	-0.00412***	-0.00193***
	(-207.18)	(-137.82)	(-372.32)	(-262.41)
Female	-0.00517***	-0.00627***	-0.00588***	-0.00683***
	(-15.47)	(-26.25)	(-17.60)	(-28.49)
White ethnicity	-0.0199***	-0.0111***	-0.0196***	-0.0104***
	(-23.38)	(-23.72)	(-26.66)	(-27.13)
Frequent attender	-0.0619***	-0.0235***	-0.0685***	-0.0263***
	(-91.32)	(-50.97)	(-88.54)	(-49.53)
Deprivation (IMD)	-0.0273***	-0.00956***	-0.0240***	-0.00689***
	(-20.67)	(-12.44)	(-17.81)	(-9.68)
Location with sparse surroundings	-0.0265***	-0.0117***	-0.0506***	-0.0188***
	(-5.89)	(-5.17)	(-7.57)	(-6.64)
GP at least 0.5km closer than ED	-0.0174***	-0.00808***	-0.0177***	-0.00812***
	(-19.22)	(-15.58)	(-20.39)	(-17.04)
ED at least 0.5km closer than GP	0.0127***	0.00729***	0.0115***	0.00631***
	(11.79)	(9.88)	(11.18)	(9.34)
Practice characteristics				
Very or Fairly Satisfied With Care (%)	-0.000114	-0.0000529	-0.000130	-0.0000591
	(-1.63)	(-1.36)	(-1.91)	(-1.64)
QOF Points 2017-18 (%)	-0.000913***	-0.000605***	-0.000826***	-0.000512***
	(-12.58)	(-14.83)	(-11.72)	(-14.53)
GPPS Response Rate (%)	-0.000197	-0.000134*	-0.000182	-0.000101
	(-1.57)	(-2.02)	(-1.62)	(-1.64)
Full-time GPs per 1000 patients	-0.00309	-0.000344	-0.00307	0.000132
	(-1.21)	(-0.28)	(-1.22)	(0.11)
General availability: GPPS reports				
Aware of weekday AM extended hours (%)	-0.000142*	-0.0000474	-0.000152*	-0.0000576
	(-2.00)	(-1.24)	(-2.14)	(-1.57)
Aware of weekday PM extended hours (%)	0.0000210	-0.0000204	0.0000323	-0.00000242
	(0.27)	(-0.47)	(0.42)	(-0.06)
Aware of Saturday extended hours (%)	0.000133	0.000105*	0.000113	0.0000835*
	(1.70)	(2.41)	(1.48)	(2.12)
Able to book same day appointment (%)	-0.000190***	-0.0000641**	-0.000171***	-0.0000580**
	(-4.44)	(-2.99)	(-4.13)	(-2.83)
Able to book next day appointment (%)	-0.000163	-0.000104*	-0.000128	-0.0000816
	(-1.73)	(-2.07)	(-1.42)	(-1.76)
General availability: extended hours				
Practice Weekday AM	0.00109*	0.0000908	0.00105*	0.000129
	(2.28)	(0.38)	(2.27)	(0.60)

Table S5. Full results from LPM and logit regression models.

Practice Weekday AM	0.000378	0.0000692	0.000327	0.0000809
	(0.88)	(0.30)	(0.78)	(0.37)
Practice Saturday	0.00170	0.000929	0.00188	0.00140
	(1.07)	(1.05)	(1.19)	(1.72)
Practice Sunday	-0.00293	-0.000989	-0.00294	-0.00154
	(-1.01)	(-0.58)	(-1.06)	(-1.00)
Group Weekday AM	-0.000283	-0.000185	-0.000187	-0.0000792
	(-0.51)	(-0.62)	(-0.34)	(-0.29)
Group Weekday PM	-0.000412	-0.0000927	-0.000419	-0.000165
	(-0.67)	(-0.39)	(-0.71)	(-0.74)
Group Saturday	0.00220	-0.000801	0.00153	-0.000281
	(0.65)	(-0.57)	(0.46)	(-0.20)
Group Sunday	0.00200	0.00238*	0.00278	0.00235*
	(0.80)	(2.20)	(1.06)	(2.12)
Specific availability: attend in extended hour				
Practice Weekday AM	0.00136	0.00290	0.00117	0.00363*
	(0.53)	(1.77)	(0.48)	(2.10)
Practice Weekday PM	-0.00341**	-0.000804	-0.00306*	-0.000761
	(-2.64)	(-0.88)	(-2.51)	(-0.91)
Practice Saturday	-0.00524**	-0.000383	-0.00441**	-0.000631
	(-2.86)	(-0.29)	(-2.70)	(-0.53)
Practice Sunday	0.00242	0.000297	0.000384	-0.000267
	(0.60)	(0.10)	(0.12)	(-0.11)
Group Weekday AM	0.00205	0.00467	0.00199	0.00513
	(0.44)	(1.47)	(0.45)	(1.62)
Group Weekday PM	0.000174	0.00137	-0.000292	0.000751
	(0.15)	(1.61)	(-0.26)	(0.97)
Group Saturday	-0.00487**	0.000274	-0.00602***	-0.000766
	(-2.79)	(0.22)	(-3.91)	(-0.67)
Group Sunday	-0.00546**	-0.000302	-0.00757***	-0.00132
	(-3.15)	(-0.25)	(-5.17)	(-1.21)
Attendance Time				
Monday AM Extended hour at time of attendance	0.0147***	-0.0126***	0.0155***	-0.0122***
	(6.45)	(-8.71)	(7.20)	(-7.59)
Monday PM Extended hour at time of attendance	0.0137***	0.00618***	0.0133***	0.00605***
	(21.21)	(13.72)	(21.41)	(13.90)
Monday Core Hours at time of attendance	0.0116***	0.0107***	0.0102***	0.00955***
	(7.87)	(9.98)	(7.39)	(9.93)
Monday Out of hours at time of attendance	-0.0363***	-0.0104***	-0.0384***	-0.0111***
	(-36.23)	(-15.20)	(-37.01)	(-16.00)
Tuesday AM Extended hour at time of attendance	0.0117***	-0.0125***	0.0124***	-0.0124***
	(5.13)	(-8.39)	(5.71)	(-7.48)
Tuesday PM Extended hour at time of attendance	0.00362***	0.00163***	0.00350***	0.00156***
	(5.82)	(3.66)	(5.73)	(3.54)

Tuesday Core Hours at time of attendance	0.00569***	0.00458***	0.00463**	0.00408***
	(3.78)	(4.20)	(3.26)	(4.06)
Tuesday Out of hours at time of attendance	-0.0367***	-0.0122***	-0.0388***	-0.0132***
	(-37.52)	(-18.59)	(-38.33)	(-19.48)
Wednesday AM Extended hour at time of attendance	0.0107***	-0.0102***	0.0117***	-0.00979***
	(4.70)	(-6.57)	(5.38)	(-5.82)
Wednesday PM Extended hour at time of attendance	0.00343*	0.00301**	0.00242	0.00264**
	(2.32)	(2.87)	(1.73)	(2.69)
Wednesday Out of hours at time of attendance	-0.0393***	-0.0130***	-0.0417***	-0.0140***
	(-39.89)	(-19.29)	(-40.72)	(-20.13)
Thursday AM Extended hour at time of attendance	0.00546*	-0.0131***	0.00674**	-0.0130***
	(2.39)	(-8.86)	(3.05)	(-7.84)
Thursday PM Extended hour at time of attendance	-0.00194**	-0.000803	-0.00192**	-0.000856
	(-3.15)	(-1.83)	(-3.14)	(-1.94)
Thursday Core Hours at time of attendance	0.00158	0.00203	0.000943	0.00192
	(1.03)	(1.88)	(0.65)	(1.89)
Thursday Out of hours at time of attendance	-0.0406***	-0.0141***	-0.0432***	-0.0153***
	(-40.08)	(-21.74)	(-41.03)	(-22.67)
Friday AM Extended hour at time of attendance	0.00531*	-0.0118***	0.00654**	-0.0115***
	(2.32)	(-8.06)	(2.94)	(-7.07)
Friday PM Extended hour at time of attendance	-0.00301***	-0.000691	-0.00291***	-0.000753
	(-4.84)	(-1.57)	(-4.69)	(-1.69)
Friday Core Hours at time of attendance	-0.00246	0.00219*	-0.00266	0.00222*
	(-1.56)	(2.01)	(-1.74)	(2.13)
Friday Out of hours at time of attendance	-0.0453***	-0.0145***	-0.0485***	-0.0157***
	(-45.86)	(-22.17)	(-46.39)	(-23.02)
Saturday AM Extended hour at time of attendance	0.0460***	0.0116***	0.0445***	0.0121***
	(29.77)	(10.76)	(32.18)	(11.71)
Saturday Out of hours at time of attendance	-0.0156***	-0.00437***	-0.0166***	-0.00496***
	(-20.80)	(-8.63)	(-22.17)	(-9.82)
Sunday AM Extended hour at time of attendance	0.0523***	0.0118***	0.0500***	0.0120***
	(38.75)	(12.60)	(42.18)	(13.54)
Sunday Out of hours at time of attendance	-0.0124***	-0.00570***	-0.0133***	-0.00619***
	(-16.05)	(-11.06)	(-17.45)	(-12.13)

Note. Observations 10,161,346. Average marginal effects are reported for all specifications. Regressions include fixed effects for ED attended. Deprivation: IMD rank rescaled so that *higher* rank indicates *greater* deprivation. Robust standard errors in parentheses: *** p<0.001, ** p<0.01, ** p<0.05.

Table S6. Results from models without GPPS general availability variables

Definition of avoidable attendance:	Inappropriate	Non-urgent
Estimation:	LPM	LPM

Attender characteristics		
Age (years)	-0.00397***	-0.00178***
	(1.92e-05)	(1.29e-05)
Female	-0.00517***	-0.00626***
	(0.000335)	(0.000239)
White ethnicity	-0.0199***	-0.0111***
	(0.000862)	(0.000472)
Frequent attender	-0.0619***	-0.0235***
	(0.000678)	(0.000461)
Deprivation (IMD)	-0.0280***	-0.00983***
	(1.34e-05)	(7.85e-06)
Location with sparse surroundings	-0.0266***	-0.0117***
8.	(0.00447)	(0.00224)
GP at least 0.5km closer than ED	-0.0174***	-0.00812***
	(0.000910)	(0.000522)
FD at least 0.5km closer than GP	0.0128***	0.00731***
ED at least 0.5km closer than Of	(0.0120)	(0.00751)
Practice characteristics	(0.00100)	(0.000710)
Very or Eairly Satisfied With Care (%)	-0.000130	-6.24e-05
Very of Fairly Satisfied With Care (70)	(6.78 ± 0.5)	(3, 63, 05)
OOE Points 2017 18 $(\%)$	0.000106	0.000134*
QOI 10IIIII 2017-18 (70)	(0.000190)	(6.672.05)
CDDS Desponse Date $(\%)$	0.000127)	0.00612***
OI I S Response Rate (70)	(7, 20, 05)	-0.000012
Eull time CDs per 1000 petients	(7.30e-03)	(4.136-03)
Full-time GPS per 1000 patients	-0.00340	-0.000447
	(0.00258)	(0.00125)
General availability: extended nours	0.000506	7.05.05
Practice Weekday AM	0.000586	-/.95e-05
	(0.000393)	(0.000200)
Practice Weekday AM	0.000470	4.76e-05
	(0.000403)	(0.000218)
Practice Saturday	0.00376**	0.00248***
	(0.00124)	(0.000696)
Practice Sunday	-0.00376	-0.00144
	(0.00294)	(0.00167)
Group Weekday AM	-0.000262	-0.000188
	(0.000560)	(0.000295)
Group Weekday PM	-0.000395	-7.06e-05
	(0.000620)	(0.000238)
Group Saturday	0.00212	-0.000919
	(0.00342)	(0.00141)
Group Sunday	0.00209	0.00246*
	(0.00252)	(0.00110)
Specific availability: attend in extended hour		
Practice Weekday AM	0.00138	0.00291
	(0.00256)	(0.00164)
Practice Weekday AM	-0.00340**	-0.000799
	(0.00129)	(0.000916)
Practice Saturday	-0.00524**	-0.000374
	(0.00183)	(0.00130)
Practice Sunday	0.00236	0.000253
	(0.00401)	(0.00298)
Group Weekday AM	-0.00486**	0.000279
	(0.00175)	(0.00123)
Group Weekday PM	-0.00546**	-0.000300
	(0.00173)	(0.00122)
Group Saturday	0.00202	0.00466
	(0.00464)	(0.00317)
Group Sunday	0.000171	0.00137
	(0.00119)	(0.000852)
Attendance Time	(*******)	(
Monday AM Extended hour at time of attendance	0.0146***	-0.0126***
	(0.00228)	(0.00145)
Monday PM Extended hour at time of attendance	0.0116***	0.0107***
	(0.00148)	(0.00108)
Monday Core Hours at time of attendance	0.0137***	0.00618***

	(0.000644)	(0.000450)
Monday Out of hours at time of attendance	-0.0363***	-0.0104***
	(0.00100)	(0.000682)
Tuesday AM Extended hour at time of attendance	0.0117***	-0.0126***
	(0.00229)	(0.00150)
Tuesday PM Extended nour at time of attendance	0.00569***	0.0045/***
Tuesday. Core Hours at time of attendance	0.00151)	0.00163***
ruesday core mours at time of attendance	(0.00000000000000000000000000000000000	(0.00103)
Tuesday Out of hours at time of attendance	-0.0367***	-0.0122***
ruesday out of nours at time of attendance	(0.000979)	(0.000658)
Wednesday AM Extended hour at time of attendance	0.0107***	-0.0102***
•	(0.00228)	(0.00155)
Wednesday PM Extended hour at time of attendance	0.00344*	0.00301**
	(0.00148)	(0.00105)
Wednesday Out of hours at time of attendance	-0.0394***	-0.0130***
	(0.000987)	(0.000674)
Thursday AM Extended hour at time of attendance	0.00547*	-0.0131***
	(0.00228)	(0.00148)
Thursday PM Extended hour at time of attendance	0.00160	0.00203
	(0.00153)	(0.00108)
Inursday Core Hours at time of attendance	-0.00194^{**}	-0.000803
Thursday Out of hours at time of attendence	(0.000618)	(0.000440) 0.0141***
Thursday Out of hours at time of attendance	(0.0400^{+++})	(0.00141)
Friday AM Extended hour at time of attendance	0.00530*	-0.0118***
Thay The Extended nour at time of attendance	(0.00229)	(0.00146)
Friday PM Extended hour at time of attendance	-0.00249	0.00217*
	(0.00157)	(0.00109)
Friday Core Hours at time of attendance	-0.00301***	-0.000693
-	(0.000621)	(0.000441)
Friday Out of hours at time of attendance	-0.0453***	-0.0145***
	(0.000987)	(0.000655)
Saturday AM Extended hour at time of attendance	0.0460***	0.0116***
	(0.00155)	(0.00108)
Saturday Out of hours at time of attendance	-0.0156***	-0.00438***
	(0.000752)	(0.000507)
Sunday AM Extended hour at time of attendance	0.0523***	0.0118***
Sunday Out of hours at time of attendance	(0.00135)	(0.000939)
Sunday Out of nours at time of attendance	-0.0124^{++++}	-0.00370^{++++}
Constant	0.608***	(0.000313) 0.287***
Constant	(0.0134)	(0.00677)
Observations	10 161 246	10 161 246
P_squared	0.002	0.055
	0.020 9.796e±06	3 128e±06
BIC	9.798e+06	3.131e+06

Note. Models also include fixed effects for ED attended. Observations 10,161,346. Average marginal effects are reported for all specifications. Deprivation: IMD rank rescaled so that *higher* rank indicates *greater* deprivation. Robust standard errors in parentheses: *** p<0.001, ** p<0.01, * p<0.05.



Figure S1. Weekly pattern of avoidable attendances.

Note. Averages from estimation sample. Grey shading: slots when extended general practice opening hours are most likely.

Figure S2. Attendances and inappropriate attendance against age



Note: Using inappropriate definition of attendance as a measure of avoidable attendance.

Figure S3. Marginal effects of attendance time on probability that attendance is nonurgent



Note: Average marginal effects from the Linear Probability Model reported in Table 5 and Online Supplementary Appendix Table S.3. Wednesday Core Hours (08.00-18.30) is omitted time slot.