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Choosing and Booking – and Attending? Impact of an Electronic Booking System on Outpatient Referrals and Non-attendances

Mark Dusheiko, Hugh Gravelle

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[12]Mark Dusheiko
[1]Hugh Gravelle

[1]Centre for Health Economics, University of York, UK
[2]Institut Univesitaire de Medicine Preventive et Social, Université de Lausanne, Lausanne, Switzerland

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Centre for Health Economics
Alcuin College
University of York
York, UK
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Abstract

An electronic booking system (Choose and Book – C&B) for general practices making hospital outpatient appointments was introduced in England in 2005 and by 2009 accounted for 50% of appointments. It was intended, inter alia, to reduce the rate of non-attendance at outpatient appointments (7.1% in 2004). We test whether it did so using a 2004-2009 panel with 7900 English general practices. We estimate that the use of C&B was associated with a reduction in non-attendances of 85,600 (15.8%) and a reduction in referrals of 358,000 (3%) in 2009.

JEL Nos: I10; I18

Keywords: referrals; non-attendance; outpatients; general practice; gatekeeping

1 Introduction

In the English National Health Service (NHS), health care is funded from taxation and provided without charge to patients. There is a gatekeeping system for access to hospital for non-emergency care. Patients are registered with general practices and must be referred by their general practitioner (GP) to a hospital outpatient department for diagnostic tests, treatment, or to be placed on a waiting list for elective inpatient care. In 2009 there were 11.87M first referrals by GPs to outpatient departments. Patients did not attend and did not cancel in 7% of these appointments.[1]

Non-attendance is associated with worse health outcomes for non-attenders (Hamilton *et al* 2002; Karter *et al*, 2004; Nelson *et al*, 2000; Sharp and Hamilton, 2001; Shectman et al, 2008). Although hospitals can overbook appointments, non-attendance is also costly (Bech, 2005). Over-booking increases uncertainty for patients about their waiting time at clinics when they attend. To the extent that missed appointments are not filled by other patients, non-attendance also increases waiting times for all patients.[2]

In 2005 the NHS introduced an electronic booking system – Choose and Book (C&B) – which enabled GPs and patients to book an outpatient appointment online from the GP surgery, or later online or by phone, with a choice of location, date and time. The system was introduced partly to help patients exercise a new right to a wider choice of hospital implemented in 2006 (Department of Health, 2004) but another of its aims was to reduce patient non-attendance (NAO, 2005). In this paper we use a rich new practice level data set to examine whether the introduction of C&B was associated with reduced non-attendance of GP practice patients at outpatient appointments.

Previous studies have found that male gender, age, low socioeconomic status, waiting time, and distance increase non-attendance rates (Hamilton et al 2002; Corfield et al, 2008; Sola-Vera et al, 2008; Hon et al, 2005; Lee et al, 2005). Reminders by telephone, text message, and post have been shown to reduce non-attendance rates, (Guy et al, 2012; Gurol-Urganci et al, 2013).

There have been a few small scale studies of the impact of C&B on patient non-attendance for particular specialities. Modayil et al (2009) found non-attendance rates to be 6% higher for patients using C&B compared with traditional GP referrals in an ENT department. Beckingsale and Wallace (2009) reported a 39% rise in non-attendance rates in an orthopaedic department after the introduction of C&B. By contrast, Elloy et al. (2011) compared non-attendance rates in an ENT department two years prior to and two years post C&B implementation and found a significant reduction from 7% to 5%. Parmar et al. (2009) report that attendance rates at an audiology department were 12% higher for referrals via C&B compared with non-C&B referrals, though C&B patients were older than non-C&B referrals.

We improve on previous studies of the impact of C&B in a number of ways. First, we allow for the possibility that C&B may also have altered the number of referrals as well as the probability of a referred patient failing to attend. Both effects have health and cost implications. To guide the empirical analysis and the interpretation of results, we sketch a simple model of the decisions to book an outpatient appointment and then whether to attend a booked appointment. We then show how the introduction of C&B could have led to either increases or decreases in general practice

[1] Some patients referred by their GP and seen by an outpatient consultant may have subsequent outpatient appointments made by the outpatient consultant. We exclude outpatient appointments cancelled by hospitals from the denominator in computing the patient cancellation rate.

[2] NHS England estimate missed outpatient appointments had an average cost of £108 in 2012/13, implying that missed first GP referral appointments would have cost £80 million; it is unclear whether this allows for overbooking. https://www.england.nhs.uk/2014/03/05/missed-appts/ Last accessed 14 04 15.

referral rates and in the probability of non-attendance given that a referral has been made. Second, we also investigate whether C&B affected patient and hospital propensities to cancel booked appointments. Third, we have new panel data on the use of C&B by every general practice in England over a six year period from 2004 to 2009. We identify the effects of C&B by using changes over time within practices in the proportion of referrals made using the C&B, thereby allowing for unobserved time invariant factors operating at practice level which might affect both the propensity to use C&B and practice referral and non-attendance rates.

In 2009 C&B was used to make 50% of GP first appointments at hospital outpatient departments. We estimate that in the absence of C&B there would have been 85,594 (15.8%) more non-attended appointments and 358,449 (3%) more referrals.

Our analysis contributes to the limited evidence on the effects of large scale investment in health information technology (HIT). The US Health Information Technology for Economic and Clinical Health Act of 2009 provided $27 billion for incentive payments and investment (Blumenthal and Tavenner, 2010). The NHS spent £280 million on the C&B system up to 2012 (Department of Health, 2013). It is hoped that such investment in HIT will increase the productivity and efficiency of healthcare via cost reductions, improvements in safety and quality, and enabling greater patient empowerment in treatment decisions. But large HIT investment projects frequently have significant cost overruns, fail to fulfil objectives, and there is uncertainty about the value obtained from the investment (Bassi and Lau, 2013) with mixed evidence on the impact of HIT in reducing costs or improving health outcomes (Encinosa and Bae, 2011; Lapointe et al, 2011). This paper is one of the few studies to have examined the impact of a national HIT programme on processes and outcomes of healthcare delivery.

In the next section we develop a model of the decisions to book an outpatient appointment and to attend when booked. Section 3 describes the data and section 4 sets out our estimation strategy. Section 5 has the results and Section 6 discusses their interpretation in the light of the close relationship between C&B and the lifting of restrictions on patient choice of provider in 2006.

2 Referrals, non-attendance, and Choose and Book

2.1 A model of referrals and non-attendance

In this section we sketch a model of the decisions to book an outpatient appointment, and then whether to attend the booked appointment. We use it to consider how the introduction of C&B might have changed these decisions and hence changed general practice outpatient referral rates and non-attendance rates for referred patients. The model captures two key features of the booking and attendance decisions. First, they are separated in time, and so, between making a booking and the day of appointment, new information may be acquired about the benefits and costs of the appointment. Second, the referral decision is influenced by the payoffs to the GP and the patient, whereas the attendance decision is made by the patient who takes account only of her payoff from attending.

At date 0 a decision is made to book an outpatient appointment for date t. At the appointment date t the patient incurs a cost of c if she decides to attend. The benefit b to the patient from the appointment accrues some time s after she keeps the appointment.[3] The patient payoff from failing to attend is V_{NA}. The patient's payoff from attending the appointment, evaluated at the appointment date t, is $\delta(s)b - c$. $\delta(s) = \exp(-\rho s)$ is her discount factor with $\rho > 0$. She will attend the booked appointment if and only if $\delta(s)b - c \geq V_{NA}$ or if realised attendance cost is less than the threshold $\hat{c}$:

$$c \leq \hat{c}(b; z_A) \equiv \delta(s)b - V_{NA} \tag{1}$$

where z_A is the vector of parameters, other than b, affecting the attendance decision. At date 0 when the appointment is made there is perfect information[4] about the benefit b from the appointment but attendance cost is uncertain and has a distribution function $F(c,\lambda^c)$. Here λ^c is a shift parameter which may be altered by the introduction of Choose and Book. At date t, just before the appointment, the patient gets perfect information about the realised cost c. The probability that the patient with benefit b will not attend the booked appointment is $1 - F(\hat{c}(b; z_A), \lambda^c)$.

The referral decision is made at date 0 by a semi-altruistic GP who realises that the patient will decide at date t whether to attend given her information on the realised attendance cost. The referral is made if and only if

$$V(\hat{c}(b, z_A), b, z_B, \lambda^c, \alpha) = \alpha V^P - (1 - \alpha) c_B^{GP} \geq 0 \tag{2}$$

where the patient's expected gain from the referral is

$$V^P = \int_0^{\hat{c}(b,z_A)} \left[\delta(t+s)b - \delta(t)c\right] f(c, \lambda^c) dc + \left[1 - F(\hat{c}(b, z_A), \lambda^c)\right] \delta(t) V_{NA} - c_B \tag{3}$$

[3] The outpatient appointment may be for diagnostic tests to inform future GP treatment or to have the patient seen by a specialist to determine if they require future elective hospital treatment.

[4] Equivalently *b* could be the patient's expected benefit conditional on information at date 0 and no new information on benefit is acquired before the attendance date. More complicated, but yielding similar insights, we could have a joint prior distribution of costs and benefits at date 0 with information on *b*, *c* arising before the attendance date and yielding a posterior joint distribution on the basis of which the attendance decision is taken.

$\alpha > 0$ is the weight the GP places on patient utility. c_B and c_B^{GP} are the costs of booking borne by the patient and GP and include both time costs from a longer consultation and the opportunity cost of not booking.[5]

z_B is the vector of parameters, other than b, which affect expected utility from booking an appointment at date 0 but which do not affect the attendance decision. For example, a change in the patient booking cost c_B will alter the decision to book but will not alter the decision to attend if booked because it is a bygone cost at date t. Conversely, elements in z_A which affect the attendance decision will also affect the booking decision since anything that affects patient utility from attending when booked must affect patient expected utility V^P from booking and hence V.

Since V is increasing in patient benefit b, a booking will be made for all patients whose benefit is greater than the referral threshold $\hat{b}(z_A, z_B, \lambda^c)$, defined implicitly by $V = 0$.[6] The benefit is distributed across the population of patients in the practice according to the distribution function $G(b,\lambda^b)$. Hence the proportion of patients in the practice who are referred (the practice referral rate) is

$$r = r(\hat{b}(z_A, z_B, \lambda^c), \lambda^b) = 1 - G(\hat{b}(z_A, z_B, \lambda^c), \lambda^b). \quad (4)$$

The non-attendance rate n is the proportion of patients who have made an appointment and do not attend (i.e. have $b > \hat{b}(z_A, z_B, \lambda^c)$ and $c > \hat{c}(b, z_A)$):

$$n = \frac{\int_{\hat{b}(z_A, z_B, \lambda^c)}^{\infty} \int_{\hat{c}(b, z_A)}^{\infty} f(c, \lambda^c) g(b, \lambda^b) dc db}{1 - G(\hat{b}(z_A, z_B, \lambda^c), \lambda^b)} = \frac{\int_{\hat{b}(z_A, z_B, \lambda^c)}^{\infty} [1 - F(\hat{c}(b, z_A), \lambda^c)] g(b, \lambda^b) db}{1 - G(\hat{b}(z_A, z_B, \lambda^c), \lambda^b)} \quad (5)$$

Figure 1 illustrates. With uncertain attendance cost patients in (i) and (ii) with benefit $b \geq \hat{b}$ are referred. At date t those in (i) with realised attendance cost $c \leq \hat{c} = \delta(s)b - V_{NA}$ attend and the non-attendance rate is the probability mass in (ii) as a proportion of the probability mass in (i) and (ii).

[5] Whether the patient attends the appointment or not may also affect future GP costs. If she attends she will usually require a subsequent GP consultation to discuss the results of tests etc. But any expected improvement in health from keeping the appointment could reduce GP costs. If future GP costs depend on whether the patient attends then changes in the patient attendance decision will affect the referral decision. To simplify we assume that the net effect on the GP of whether the patient attends is negligible.

[6] Remembering that $\hat{c}$ is chosen by the patient at date *t*,

$$\frac{dV}{db} = \alpha\left(\frac{\partial V^P}{\partial b} + \frac{\partial V^P}{\partial \hat{c}}\frac{\partial \hat{c}}{\partial b}\right) = \alpha\delta(t+s)F(\hat{c}, \lambda^c) + \alpha\delta(t)[\delta(s)b - \hat{c} - V_{NA}]f(\hat{c}, \lambda^c)\frac{\partial \hat{c}}{\partial b} = \alpha\delta(t+s)F(\hat{c}, \lambda^c) > 0$$

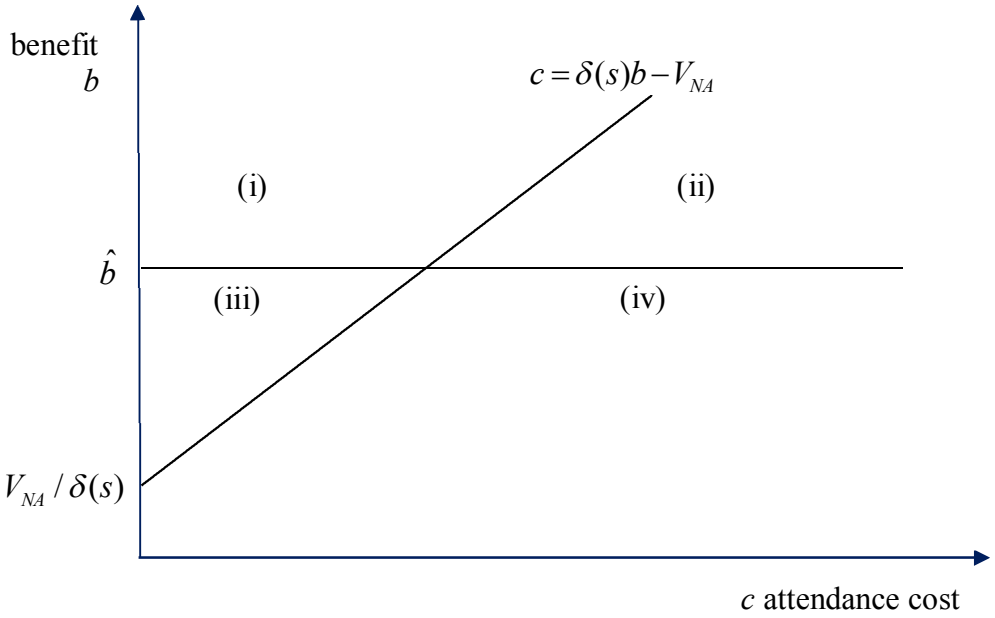

Figure 1. Patient referral and attendance

Notes. With uncertain attendance cost patients in (i) and (ii) with benefit $b \geq \hat{b}$ book and those in (i), with realised attendance cost $c \leq \hat{c} = \delta(s)b - V_{NA}$ then attend. The referral rate r is the number of patients in (i) and (ii) divided by the total number (the sum of (i), (ii), (iii), and (iv)). The non-attendance rate n is the number of patients in (ii) divided by the number in (i) and (ii).

Consider the effect of a change in z_B which increases the referral threshold $\hat{b}$ and has no effect on $\hat{c}(b, z_A)$. This will clearly reduce the referral rate (4) which is the denominator in (5). It will also reduce the numerator $\int_{\hat{b}}^{\infty} [1 - F(\hat{c}(b, z_A))] dG(b, \lambda^b)$. Despite the fact that both the numerator and denominator in (5) are reduced, the non-attendance rate will fall if $\hat{b}$ increases. Intuitively, the marginal patients (with $b = \hat{b}$) who are not referred when $\hat{b}$ increases would have had higher probability of not attending than the average infra-marginal referred patient (with $b > \hat{b}$) because they have lower benefit and so are more likely to be deterred when the attendance cost is realised.[7] Components of z_B which increase the referral threshold will reduce the referral rate r *and* the non-attendance rate n.

[7] Formally,

$$\frac{\partial n}{\partial \hat{b}} = \frac{1}{[1 - G(\hat{b}, \lambda^b)]^2} \left\{ -[1 - F(\hat{c}(\hat{b}, z_A), \lambda^c)][1 - G(\hat{b}, \lambda^b)] + \int_{\hat{b}}^{\infty} [1 - F(\hat{c}(b, z_A), \lambda^c)] g(b, \lambda^b) db \right\} g(\hat{b}, \lambda^b)$$

$$= \frac{1}{[1 - G(\hat{b}, \lambda^b)]^2} \left\{ \int_{\hat{b}}^{\infty} [F(\hat{c}(b, z_A), \lambda^c) - F(\hat{c}(\hat{b}, z_A), \lambda^c] dG(b, \lambda^b) \right\} g(\hat{b}, \lambda^b) < 0$$

Thus, in Table 1, greater weight being placed on the effect of a referral on the patient – an increase in α in the formal model – would lead to an increase in the referral rate r because the referral cost for the GP would carry a lower weight, thereby increasing the weighted gain V from referral.[8] An increase in the booking costs of the GP (c_B^{GP}) and the patient (c_B) and a longer waiting time for the appointment (t) will also reduce expected discounted utility from referral, and hence increase the referral threshold, and reduce both the referral rate r and the non-attendance rate n.

Table 1. Booking and attendance decisions: comparative statics

	Change in decisions			
Increase in	Attendance threshold $\hat{c}$	Referral threshold $\hat{b}$	Referral rate r	Non-attendance rate n
$\hat{b}$	.	.	–	–
$\hat{c}$	.	.	0	–
α	0	–	+	+
c_B^{GP}	0	+	–	–
c_B	0	+	–	–
t	0	+	–	–
V_{NA}	–	–	+	+
s	–	+	–	?
λ^c FSD	0	+	–	–
λ^c MPS	0	–	+	+
λ^b FSD	0	0	+	?

Notes. b certain benefit for patient at date $t+s$ from attending at date t, c cost of attendance at date t, V_{NA} expected utility at date t if do not attend. $\delta(\cdot)$ discount factor. Patient attends at date t if attendance cost c realised at date t is less than the threshold $\hat{c} = \delta(s)b - V_{NA}$. $F(c,\lambda^c)$ distribution function for attendance costs. c_B, c_B^{GP} patient, GP cost of booking. α weight on patient utility in referral decision. Appointment booked at date 0 if benefit b exceeds threshold $\hat{b}$. $G(b, \lambda^b)$ distribution function of benefit across patient population. Referral rate $r = 1 - \mathrm{G}(\hat{b}, \lambda^b)$. Non-attendance rate $n = \int_{\hat{b}}[1 - F(\hat{c}(b,\cdot),\lambda^c)]g(b,\lambda^b)db \,/[1 - \mathrm{G}(\hat{b}, \lambda^b)]$. FSD: increase in λ leads to first order stochastic dominant distribution ($F_{\lambda^c} < 0,\ G_{\lambda^b} < 0$). MPS: increase in λ is mean preserving spread in distribution.

Now consider the effect on the referral and non-attendance rates of increases in the elements in z_A which affects both $\hat{b}(z_A, z_B, \lambda^c)$ and $\hat{c}(b, z_A)$. The attendance threshold $\hat{c}$ does not affect patient expected utility from booking (V^P) because $\hat{c} = \delta(s)b - V_{NA}$ is optimally chosen by the patient at date t. Hence the effect of an increase in z_A on the booking decision depends on the sign of (treating z_A as a scalar):

$$\frac{dV}{dz_A} = \alpha\left(\frac{\partial V^P}{\partial z_A} + \frac{\partial V^P}{\partial \hat{c}}\frac{\partial \hat{c}}{\partial z_A}\right) = \alpha\frac{\partial V^P}{\partial z_A} \tag{6}$$

An increase in V_{NA} which increases the expected utility from booking reduces the booking threshold $\hat{b}$ and increases the referral rate, whereas an increase in delay s before the benefits from the appointment are realised will have the opposite effect.

[8] Since the threshold $\hat{b}$ is defined by $\alpha V^P(\hat{b},\cdot) - (1-\alpha)c_B^{GP} = 0$, we have $V^P(\hat{b},\cdot) > 0$, and so $\partial V/\partial\alpha = V^P(\hat{b},\cdot) + c_B^{GP} > 0$, implying that the threshold will be reduced.

The effect on the non-attendance rate of changes in an element of z_A which changes both the attendance and referral thresholds is

$$\frac{dn}{dz_A} = \frac{\partial n}{\partial \hat{b}}\frac{\partial \hat{b}}{\partial z_A} + \frac{\partial n}{\partial \hat{c}}\frac{\partial \hat{c}}{\partial z_A} \tag{7}$$

We have seen that an increase in $\hat{b}$ reduces the non-attendance rate. It is obvious from (5) that an increase in $\hat{c}$, which only affects the numerator and not the denominator in the non-attendance rate, will decrease the non-attendance rate. Thus if the effects of z_A on $\hat{b}$ and $\hat{c}$ have the same signs then the overall effect of z_A on the non-attendance rate is unambiguous. An increase in V_{NA} will reduce $\hat{c}$ (since not attending is more attractive) and will also reduce $\hat{b}$ since the expected utility from referral is increased: one of the referral outcomes has improved and the other is unchanged. Hence an increase in V_{NA} will reduce the non-attendance rate. On the other hand, an increase in s will reduce $\hat{c}$ (increasing the probability of non-attendance and thus the non-attendance rate) but will increase $\hat{b}$ because one of the referral outcomes is now worse (attending) and the other unchanged, thereby reducing the non-attendance rate. Thus the effect of an increase in s on the non-attendance rate is ambiguous.

Changes in the distribution function of attendance costs $F(\hat{c},\lambda^c)$ will not affect the threshold attendance cost but will alter the gain from attending as expected at the booking date. Realised patient utility at date t is $u(c,s,V_{NA}) = \max\{\delta(s)b - c,\ V_{NA}\}$ which is decreasing or constant with respect to c. Thus a shift in λ^c which induces a first order stochastically dominating shift in the distribution of attendance costs will reduce expected patient utility from booking and hence raise the booking threshold, reducing the referral rate and the non-attendance rate.[9] Alternatively if a shift in λ^c increases uncertainty at booking date about attendance costs by inducing a mean preserving spread in the distribution of c then, because $u(c,s,V_{NA})$ is a convex function of c, expected utility from attending is increased: worse information makes the patient better off after booking. This will reduce the booking threshold, thereby increasing the referral rate and the non-attendance rate.

A first order stochastically dominating shift in the distribution of benefits across the population of potential referred patients ($G_{\lambda^b}(b,\lambda^b) < 0$) will increase the referral rate $r = (1 - \underline{G}(b,\lambda^b)$. But the effect on the non-attendance n rate is ambiguous.[10]

[9] $\delta(t)\mathrm{E}[\max\{\delta(s)b - c,\ V_{NA}] = \delta(t)\{\ \delta(s)b - \mathrm{E}[c|c \le \hat{c}\,]\mathrm{F}(\hat{c},\lambda^c) + V_{NA}\ [1 - \mathrm{F}(\hat{c},\lambda^c)]\}$.

[10] Writing $m(b) = 1 - F(\hat{c}(b,z_A),\lambda^c)$, the effect on the non-attendance rate is

$$\partial n / \partial \lambda^b = (1-G)^{-2}\left\{(1-G(\hat{b},\lambda^b))\int_{\hat{b}} m(b)g_{\lambda^b}(b,\lambda^b)db - \int_{\hat{b}} m(b)g(b,\lambda)db\int_{\hat{b}} g_{\lambda^b}(b,\lambda^b)db\right\}.$$

The second term inside $\{\cdot\}$ is positive since $m(b) > 0$ and first order stochastic dominance ($G_{\lambda^b}(\hat{b},\lambda^b) < 0$) implies $\partial[1 - G(\hat{b},\lambda^b)] / \partial\lambda^b > 0$. However, the sign of the first term is ambiguous.

2.2 Effects of Choose and Book

If the GP does not use C&B she will write to the outpatient department to request an appointment for the patient. The choice of outpatient department might be discussed with the patient. The hospital would then write to the patient with the details of the appointment slot whose timing would be decided by the hospital on receipt of the request letter from the GP. The patient could attempt to change the timing of appointment directly with the hospital by phone or letter, but would not be able to do so over the internet. See appendix Figure A1 for a description of the C&B referral process.

When the GP uses C&B she could discuss the choice of provider with the patient, register them on the C&B system, and book their preferred initial appointment together. The patient then has a C&B booking reference and can the change appointment time or location at a later date (either on the internet, by telephone, or in the practice). If the GP made the choice of provider via C&B but with no input from the patient, the hospital would inform the patient by letter. The patient would then have the C&B reference number for the appointment and could use it to change the booking.

In terms of the theory model the use of C&B could have affected both z_A, z_B and hence the decisions to refer (via $\hat{b}(z_A, z_B, \lambda^c)$) and to attend if booked (via $\hat{c}(b, z_A)$). It could also have shifted the perceived distributions of attendance cost and patient benefit, which we capture via the parameters λ^c and λ^b in $F(\mathrm{c},\lambda^c)$ and $\mathrm{G}(b,\lambda^b)$.

C&B could have increased the information available to patients about alternative outpatient departments (see Figure A2 which shows a rising trend in the proportion of patients aware of their right to a choice of provider and exercising that choice). With an appointment made via C&B, patients had the opportunity to defer the booking of an appointment from their consultation with the GP until later at home when they could log into the C&B system and make the booking themselves. This may also change the nature of the consultation between the GP and patient, leading to a more shared decision making process with more weight on patient preferences.[11] In terms of the model we expect C&B to increase the weight (α) on patient utility in the decision process and so, according to Table 1, to increase referrals and the non-attendance rate.

Booking costs (c_B^{GP}) for general practices probably increased, especially in its early phase when the software was considered cumbersome and unreliable by many GPs. GPs were financially incentivised to use the C&B system. Between April 2006 – April 2008 they were paid 49p per patient on the list if they agreed to use C&B, and a further 49p per referral if at least 50% were made via C&B. After 2008 payments continued in some Primary Care Trusts (PCTs). These incentive payments may not have offset the additional GP costs of using C&B. This would have led, ceteris paribus to a reduction in the referral rate and in the non-attendance rate for practices which perceived a higher cost of using the new system. Some patients would have had lower booking costs, especially those with better internet access, as the system made it possible for them to confirm or change appointments from home, after their GP had registered their provisional booking. Ceteris paribus this would have lowered the referral threshold, increasing referrals and the non-attendance rate. But some patients may have found it more difficult to access and use the C&B system compared with the previous system in which the GP made the appointment and so faced higher booking costs.

[11] See O'Connor et al (2004) for a review of evidence on the effect of shared decision processes on choice of treatment.

C&B made it easier for patients to cancel appointments and to rebook, thereby increasing the expected utility V_{NA} from not attending the appointment.[12] This would have increased expected utility from making an appointment and so increased the referral rate. It would also increase the non-attendance rate.

C&B improved information about benefits and costs of appointments, in particular by providing a firm appointment date earlier than under the previous arrangement where the booked date and time would not be known to the patient until the GP had contacted the outpatient clinic and the outpatient clinic had contacted the patient. C&B may also have led to a change in the distribution of the patient benefit from referral. The system software, made it easier to show patients the waiting times and quality indicators at different outpatient departments and widened the effective choice set for patients.

The introduction of C&B was part of a package of measures to develop the new internal market in the NHS. In particular, from January 2006 patients had to be given the choice of at least four providers for elective care and in April 2008 patients had the right to choose any willing provider (Dixon et al, 2010). By widening the available choice set the Choice reforms of 2006 and 2008 are likely to have increased the expected benefits from a referral. In terms of our model, wider choice sets will shift the distribution of patient benefits favourably, thereby increasing the referral rate. But the effect on the attendance rate would be ambiguous, even if the distribution of attendance costs was unchanged. In terms of Figure 1 a greater mass of patients would be in areas (i) and (ii) above the critical referral threshold, but the attendance rate could increase or decrease depending on the relative changes of the masses in (i) and (ii).

Since the use of C&B could have increased or reduced both the referral rate and the non-attendance rate, even in the absence of other policies, empirical investigation is required to establish both the direction and the magnitude of the effects of C&B. We discuss below (in the methods section 4.2 and in our discussion of the results in section 6) whether the extent to which our estimation strategy enables us to identify the effects of Choose and Book as distinct from the effects of the Choice reform or the other policies associated with the new internal market.

[12] In the interests of tractability we do not include in the model the choice between cancelling the appointment and failing to attend without giving notice to the hospital outpatient department. In terms of our model the non-attendance rate includes both patients who cancel their appointment and those who do not give notice.

3 Data

3.1 Choose and Book

Data on the number of all first GP practice referrals made using the C&B system to all hospital providers treating NHS patients by month of referral, specialty of referral, hospital of treatment and referring GP practice was obtained from NHS Connecting for Health and the Department of Health's C&B Service Utilisation Database (HSCIC, 2015).

The C&B data cover the period 1 January 2005 to 1 January 2010. The year 2005 was a pilot year with selected GP practices and hospitals participating. From 1 January 2006 C&B was launched nationally and available to all GP practices, but the system was not in place across all hospitals and specialties. Over time the system was rolled out to most hospital departments and use of C&B by GP practices increased so that by 2009, 50% of first GP outpatient appointments were booked with C&B (see Table 2 and Figure 2).

3.2 Hospital Episode Statistics

We linked the database on practice use of C&B to the English Hospital Episode Statistics (HES) Outpatient database of all outpatient appointments in English hospitals treating NHS patients. The HES data is for financial years (1 April to 31 March) and records all outpatient referrals with an appointment date from 1 April 2003 to 31 March 2010. It is therefore possible that some GP practice referrals made via C&B at the end of the 2009 calendar year are not recorded in our HES data because the appointment date was after 31 March 2010. However, in 2010 an 18 week total waiting time target from date of referral to treatment was in place and would help to ensure that the majority of patients referred before 31 December 2009 would have been scheduled to be seen before 1 April 2010. We use year dummies in the empirical analysis and this will allow for under recording of referrals made at the end of 2009.

We focus on the first scheduled outpatient appointment that was arranged following a referral from a GP practice, rather than outpatient appointments made by hospital specialists or follow up appointments. We use the HES data to derive total annual first referrals made during each of the calendar years 2004 to 2009 for all English general practices which had at least 500 registered patients during the year.

Data on annual GP practice first scheduled referrals was linked to annual GP practice C&B utilisation using the Organisational Codes Service GP practice identifier. We dropped 110 (0.20%) practice-year observations with a record of C&B utilisation but with no referrals recorded in HES. There were also 2,316 (4.13%) practice-year observations where the total recorded C&B first referrals exceeded first referrals recorded in HES.[13]

We calculate annual GP practice C&B utilisation rates B_{it}/R_{it} where B_{it} is the total number of first GP practice outpatient appointments booked using the C&B system by GP practice i in year t and R_{it} the number of first appointments made by the GP practice (referrals).

[13] The error is due to (i) a failure in HES to record GP practice codes (ranging between 3% and 5% of records for referred patients in each year, but concentrated in a small sub-set of GP practices) and (ii) inaccurate date of referral.

Table 2. Descriptive statistics 2004 – 2009

Variable	2004 Mean Std. Dev. [Min, Max]	2005 Mean Std. Dev. [Min, Max]	2006 Mean Std. Dev. [Min, Max]	2007 Mean Std. Dev. [Min, Max]	2008 Mean Std. Dev. [Min, Max]	2009 Mean Std. Dev. [Min, Max]
Referral rate	0.158 0.044 [0.002, 0.492]	0.162 0.042 [0.005, 0.047]	0.163 0.043 [0.001, 0.483]	0.169 0.044 [0.029, 0.493]	0.191 0.049 [0.036, 0.47]	0.207 0.057 [0.002, 0.499]
Non attendance rate	0.071 0.051 [0, 0.55]	0.071 0.048 [0, 0.625]	0.069 0.041 [0, 0.750]	0.068 0.037 [0, 0.556]	0.065 0.035 [0, 0.486]	0.070 0.037 [0,1]
Cancellation rate	0.034 0.048 [0,0.5]	0.035 0.046 [0, 0.4]	0.036 0.043 [0, 0.333]	0.042 0.047 [0, 0.222]	0.048 0.051 [0, 0.429]	0.054 0.051 [0, 0.25]
Attendance rate	0.895 0.074 [0.194, 1]	0.894 0.067 [0.375, 1]	0.895 0.059 [0.250, 1]	0.890 0.058 [0.333, 1]	0.887 0.060 [0.429, 1]	0.876 0.059 [0,1]
Hospital cancellation rate	0.017 0.026 [0, 0.333]	0.017 0.026 [0, 0.345]	0.021 0.027 [0,0.25]	0.024 0.030 [0, 0.286]	0.025 0.028 [0, 0.5]	0.033 0.033 [0, 0.215]
C&B rate	0 0 [0, 0]	0.745 2.556 [0, 49.582]	19.159 17.054 [0, 99.315]	38.389 24.093 [0, 100]	45.578 23.548 [0, 100]	49.233 22.729 [0, 100]
List size	6382 3836 [557, 35956]	6416 3872 [559, 36388]	6509 3908 [518, 36884]	6603 3958 [501, 37613]	6710 4011 [541, 38717]	6716 4152 [504, 39919]
List size per GP	1954 770 [309, 28067]	1910 703 [314,15767]	1846 721 [209, 10021]	1862 725 [225, 12174]	1829 761 [210, 13014]	1802 866 [26, 25855]
Number of practices	7909	8015	8004	7820	7794	7914

Notes. The denominator for non-attendance, patient cancellation, and attendance rates is referrals minus hospital cancellations; for the hospital cancellation rate and the C&B rate it is referrals; and for the referral rate it is the practice list size. Figures are for calendar years.

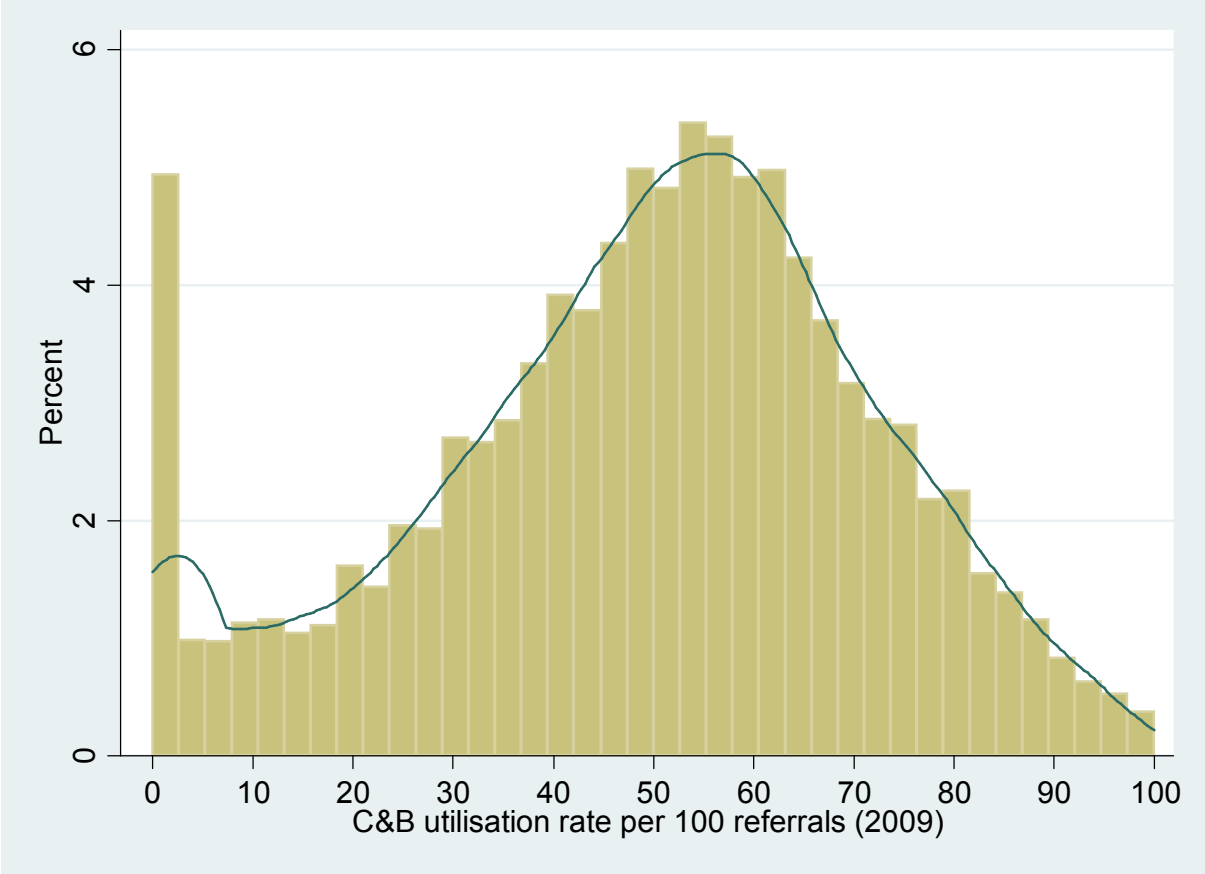

Figure 2: Distribution of GP practice Choose and Book utilisation rates for first outpatient referrals in 2009

3.3 Referral outcome measures

We examine the effect of the GP practice C&B utilisation rate B_{it}/R_{it} on the outcomes of the first scheduled appointment arranged following a referral from a GP practice. Using HES we classify attendance outcomes for referrals made during a calendar year into four categories[14]
N_{it} = number of appointments recorded as not attended with no prior warning;
C_{it} = number of first scheduled GP referred appointments cancelled by patients;
H_{it} = number of first scheduled GP practice referred appointments cancelled by the hospital;
A_{it} = number of first scheduled GP practice referred appointments attended.

In addition to the appointment outcomes we are also interested in the effect of C&B on the number of first GP referrals ($N_{it} + C_{it} + H_{it} + A_{it}$).

In some hospitals the only referral outcomes recorded were that the patient attended or that the outcome was unknown: the hospital recorded no referrals in which the patient failed to attend, or the patient cancelled, or the hospital cancelled. In 2004, 8.7% of appointments were in 29 providers that did not record outcomes other than attended or unknown. This mis-recording decreased year on year, until in 2009 where 1.9% of appointments were at 15 hospitals that only reported attendance or unknown outcomes. When computing practice referral outcomes we exclude

[14] 0.45% of appointments in hospitals recording the full range of outcomes had an unknown outcome. 0.37% of appointment records did not distinguish whether the appointment was a first or follow up appointment. We assumed that they were first appointment if the organisation referral code (*reforg*) in HES matched a valid GP practice code, and included them in the four outcome categories.

referrals to these hospitals from the denominator of the practice non-attendance, patient cancellation and hospital cancellation rates.

3.4 General Medical Service Statistics and Practice covariates

C&B utilisation and HES admission data were linked to the General Medical Services (GMS) register of GPs and their practice populations. We include a large set of time varying practice characteristics in the models as covariates (see the summary statistics in Appendix Table A1). These include the number of patients on the practice list, and the proportion of patients in 14 age by gender groups, the number of whole time equivalent GPs per patient, the mean age of GPs, the proportion of GPs who are not GP principals, the proportion who qualified in the UK, and the proportion of female GPs. We attribute socio-economic characteristics in small areas (Lower Super Output Areas - LSOAs)[15] to practices using the proportion of practice patients resident in each LSOA. From the Quality and Outcomes Framework we use data on practice disease prevalence of 11 conditions and on smoking prevalence, and 14 measures of practice organisational quality. To allow for differences in the participation of different hospital specialities in C&B we also include the proportions of each practice's first referrals to 53 specialities.

3.5 Estimation sample

There were a total of 49,987 practice-years between 2004 and 2009 that could be matched to 97.8% of HES records for first GP referrals. Excluding practices with populations less than 500 resulted in a loss of 361 (0.72%) observations, and a further 586 practice-years (1.2%) were lost for practices having C&B utilisation rates of more than 100 (where the total recorded C&B first referrals exceeded first referrals recorded in HES after linking to GMS data) or where all referrals were to hospitals that did not record non-attendance. We also excluded outlier practices with referral rates of over 50%, annual changes in referral rates of more than 100%, or registered population changes of greater than 25% compared to the subsequent year. In total we excluded 2,531 (5.1%) practice-year observations.

[15] There were 32,482 LSOAs with a minimum population of 1000 and a mean population of 1500.

4 Estimation

4.1 Regression model

We estimate Poisson count data models for GP practice patient non-attendance N_{it}, patient cancellation (C_{it}), patient attendance (A_{it}), hospital cancellation (H_{it}), and practice first referrals (R_{it}). The GP practice utilisation rate of C&B (B_{it}/R_{it}) is the explanatory variable of interest. The models contain practice covariates and practice fixed effects and time trends varying across 10 Strategic Health Authorities. For example, for patient non-attendance, the expected number of patients not attending and failing to cancel in practice i in year t is

$$E(N_{it}) = \exp\left(ln\left(N_{it} + C_{it} + A_{it} \right) + \beta_1 \left(\frac{B_{it}}{R_{it}} \right) + \beta_2 X_{it} + \sum_{t'=5}^{t'=9} \sum_j \beta_{3jt'} S_j T_{t'} + ln\theta_i \right) \quad (8)$$

N_{it} is the number of first scheduled appointments that were non-attended in practice i (i = 1, 2, 3,....., 8449) in year t (t = 2004, 2005, ...,2009). $N_{it} + C_{it} + A_{it}$ is the exposure term – the population at risk of not attending and coefficient on the $ln\,(N_{it} + C_{it} + A_{it})$ is constrained to be equal to 1.[16] X_{it} is a vector of GP practice covariates; $T_{t'}$ is a year indicator for year t', with 2004 as the omitted year. S_j is a vector of j ($j = 1, 2,...,10$) SHA indicator variables; and θ_i is a time invariant unobserved GP practice fixed effect. In the model for hospital cancellations H_{it} the exposure is $N_{it} + C_{it} + A_{it} + H_{it}$ and for the number of referrals R_{it} it is the practice list size L_{it}. We use cluster robust standard errors to relax the Poisson property that the variance equals the mean (Cameron and Trivedi, 2015) and to allow for within practice autocorrelation (Bertrand et al., 2004). Models were estimated using Stata Version 13.0.

We estimate two other Poisson fixed effects specifications. In the first we allow the coefficient on the GP practice C&B rate to vary over time as C&B developed from its pilot stage to national implementation. For example, the model for non-attendance is

$$E(N_{it}) = \exp\left(ln\left(N_{it} + C_{it} + A_{it} \right) + \sum_{t'=5}^{t'=9} \beta_{1t'} \left(\frac{B_{it'}}{R_{it'}} \right) T_{t'} + \beta_2 X_{it} + \sum_{t'=5}^{t'=9} \sum_j \beta_{3jt'} S_j T_{t'} + ln\theta_i \right) \quad (9)$$

In the second, the SHA indicators are interacted with the practice C&B rate to investigate the extent to which the impact of C&B varied across regions:

$$E\left(N_{it} \right) = \exp\left(ln\left(N_{it} + C_{it} + A_{it} \right) + \sum_{j=1}^{j=10} \beta_{1j} \left(\frac{B_{it}}{R_{it}} \right) S_j + \beta_2 X_{it} + \sum_{t'=5}^{t'=9} \sum_j \beta_{3jt'} S_j T_{t'} + ln\theta_i \right) \quad (10)$$

We carry out sensitivity analyses with three other types of estimators. The first is the Poisson model but with random practice effects. We allow for unobserved time invariant practice factors which are correlated with the practice effects by including pre-sample (2003) values of the dependent count variable divided by its corresponding exposure term as an explanatory variable, arguing that it will pick up any unobserved practice factors influencing the counts during the estimation period 2004 to

[16] Equivalently, exposure could be measured as $R_{it} - H_{it} - U_{it}$ where R_{it} is the number referred, H_{it} the number of appointments cancelled by the hospital, and U_{it} the number of appointments with an unknown outcome. As a robustness check we also estimate models for N_{it}, C_{it} and A_{it} using $R_{it} - U_{it} = N_{it} + C_{it} + H_{it} + A_{it}$ as the exposure.

2009 (Blundell et al., 2002). The second estimator is a conditional fixed effects negative binomial model (Hausman et. al, 1984). The model allows for overdispersion but requires that the unobserved heterogeneity θ_I is equal to the overdispersion parameter in the negative binomial model and that it enters the model as $\ln\theta_i$ (Guimarães, 2008). It is possible to include time invariant characteristics in the model as they will not be perfectly collinear with the fixed effects (Allison and Waterman, 2002). We make use of this to include the prior (2003) values of the dependent count variable as an explanatory. We also include higher level regional (SHA) fixed effects in the conditional practice fixed effects model. Finally, we estimate a population averaged negative binomial model with robust standard errors, clustered by GP practices. This model also includes the prior value of the dependent variable to control for time invariant practice effects.

4.2 Identification and interpretation

There are two potential problems in using the estimated models to identify the effect of the practice C&B rate on its referral outcomes and its referral rate. The first is that there may be unobserved practice characteristics influencing both their C&B rate and their referral and attendance rates. In particular, the use of C&B was a practice decision and practices with historically high non-attendance rates might have felt they had more to gain by referring patients using the C&B system. In our preferred Poisson practice fixed effects regression model we utilise the variation in C&B uptake within GP practices over time and remove differences in average (baseline) non-attendance rates between GP practices. This eliminates any bias due to an association between unobserved practice characteristics that influence non-attendance and greater use of C&B. In the other estimation methods we include the prior 2003 value of the dependent variable, arguing that this will pick up the effect of any unobserved time invariant factors correlated with use of C&B. As a robustness check, we interact the pre-sample value of the dependent variable with the year indicator variables. To the extent that C&B uptake is correlated with baseline outcomes, this will pick up heterogeneity in the trends across practices with differential uptake of C&B.

The identification strategy is analogous to a difference in differences estimation, but with a continuous level of treatment i.e. C&B uptake (Gaynor, 2013). We exploit the changes in outcomes before and after the national implementation C&B between practices with varying degrees of C&B uptake. The level of treatment is endogenous but by estimating models with practice fixed effects, or baseline 2003 values of the dependent variable, we can remove selection bias. This will yield unbiased estimates of the average effect of C&B uptake for practices adopting C&B, provided that increased use of C&B within a practice is not associated with significant changes in other unobserved GP practice characteristics that affect non-attendance (or other outcomes of interest) during the same time period. Our model specification enables us to identify the average effect of the treatment on the treated by identifying the counterfactual trend in outcomes in the absence of any C&B uptake. Furthermore, since only 1.5% of practice-years observations have zero C&B use, the estimated effects of C&B are likely to represent the average treatment effect on the population.

The second potential problem is that there are other policy changes between 2004 and 2009 which might have affected outcomes. A system of prospective pricing for hospital inpatient stays and outpatient appointments, Payment by Results (PbR), was rolled out from 2004/5 (Department of Health, 2012). There were major changes to the contract between the NHS and general practices in April 2004 (Quality and Outcomes Framework – QOF) which incentivised care for particular patient groups and could have influenced referrals for outpatient diagnosis and testing (Roland, 2004; Gillam et al, 2012). Most saliently, from January 2006 all patients had to be offered a choice of at least 4 local hospitals when making an outpatient appointment and from April 2008 patients had a right to

be referred to any hospital providing services to NHS patients (Dixon et al, 2010). To help patients make choices the NHS Choices website was introduced in 2007[17] to provide information on hospitals.

Our use of regional year interactions will absorb the effects of policies which varied by year, either nationally or regionally as well as allowing for differential trends in unobserved factors influencing outcomes across practices. We also include time varying GP practice characteristics that may have influenced C&B uptake as well as patient non-attendance. For example, the number of GP practices fell between 2004 and 2009, with a declining proportion of small single handed practices and an increasing proportion of large multi-GP practices. To control for any possible effect of practice size and staffing we include both the practice list size and the number of GPs per patient in the model. We also include time varying indicators of organisational quality of GP practices which were incentivised from 2004 and could influence referrals and non-attendance. We also include the proportion of practice referrals to over 50 specialities in each year. This should control for policies like prospective pricing and the new practice contract whose effects could vary by speciality. The specification (9) in which the coefficient on the C&B uptake rate can vary by year also allows for the possibility that the effect of C&B was affected by the introduction of these other policies.

The C&B electronic system was closely associated with, and designed to facilitate the implementation of, the Choice policy reforms of 2006 and 2008.[18] Figure A2 shows that the percentage of patients reporting being offered choice of provider at first GP referred outpatient appointment was around 45-50% between 2007 and 2010 (Dixon, 2010). This is similar to our observed C&B uptake rate, which increased from 38% to 49% between 2007 and 2009. Given that GPs were incentivised financially for using the C&B system it seems likely that GPs offering choice would be more likely to use the C&B system. An evaluation Dixon et al (2010) found that, across 4 Primary Care Trusts (PCT), there was high correlation in 2007/8 between use of C&B and the proportion of patients reporting being offered a choice of provider.

We do not observe GPs' propensity to offer a wider choice of hospital, which raises the possibility that the estimated coefficient on C&B uptake picks both the effect of the booking technology and differences in GPs' propensity to offer wider choice. However, the use of practice fixed effects will control for time invariant GP characteristics. The use of year by region fixed effects will also control for common time varying changes in the propensity to offer choice. GP propensity to offer choice may vary over time across practices because of changes in the demographic mix of patients, or changes in the prevalence of conditions, or changes in the mix of GPs in a practice. Our use of rich set of time varying patient and GP characteristics should control for practice level heterogeneous changes in the propensity to offer choice. We argue therefore that the coefficient on the practice C&B uptake rate is an estimate of the effect of the changing use of the C&B.

[17] Other countries which have introduced web based information systems to facilitate greater choice of hospital include Norway in 2001 (Kjerstad and Kristiansen, 2005), Denmark in 2003, and Sweden in 2005 (Ranerup, 2008).

[18] The evaluation of Choice policy by the Kings Fund (Dixon et al, 2010, p.41) noted that "GPs, in particular, conflated patient choice with Choose and Book, in part because it is through this system of booking that the policy of patient choice is 'enacted'".

5 Results

5.1 Descriptive statistics

Table 2 shows that under 1% of GP practice referrals were booked using C&B during the pilot year 2005. This increased to 20% in the first year of the national system in 2006 and by 2009, 50% of GP practice first referrals were booked using C&B. There was wide dispersion in utilisation of C&B across practices in 2009 (Figure 2) with a near normal distribution apart from the lower tail with a concentration of practices with usage rates below 20% and with 5% of practices with rates of utilisation at or near zero.

Figure 3 shows the frequency distribution of patient non-attendance rates across practices for 2009. It is heavily skewed to the right and over 85% of practices had non-attendance rates below 10%.

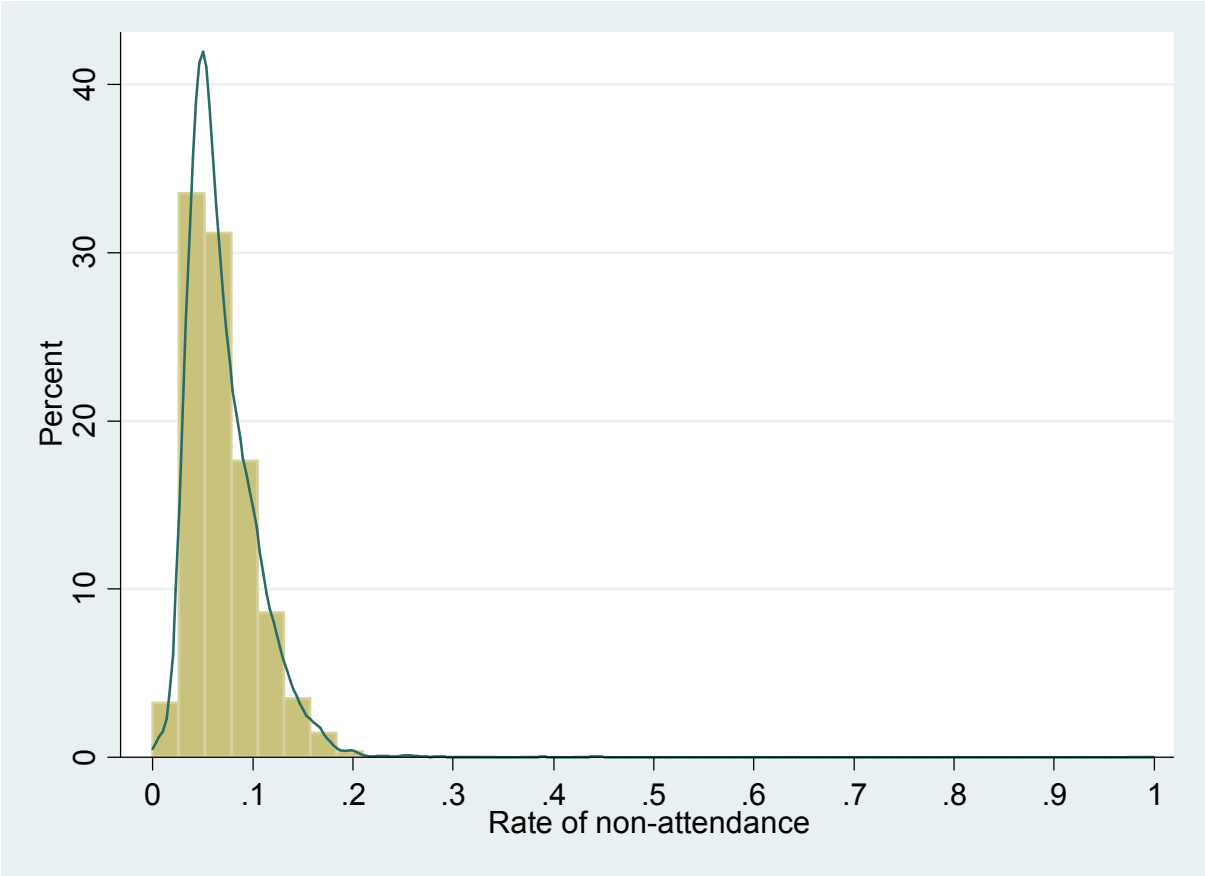

Figure 3: Frequency distribution of GP practice non-attendance rates for first scheduled outpatient appointments in 2009.

Notes. Denominator for non-attendance rate is total referrals minus hospital cancellations.

In 2004 patient non-attendance with no prior warning was the second most likely attendance outcome with around 7% of first scheduled appointments failing to attend. The rate of non-attendance remained fairly constant, apart from a dip to 6.5% in 2008. By contrast there was a relatively large increase in the rate of patient cancellations from 3.4% in 2004 to 5.4% in 2009. The 2% decline in hospital attendance rates over the period is accounted for by the increase in patient cancellations. Hospital cancellations nearly doubled from 1.7% in 2004 to over 3.3% in 2009.

There was an increase in GP practice referral rates from 158 per 1000 patients in 2004 to 207 per 1000 by 2009, with particularly large increases in 2008 and 2009. In addition to any effect of C&B, this increase in the numbers of scheduled first GP appointments may have been due to the PbR system (Imison and Naylor, 2010). There was a rapid rise in the number of consultant to consultant referrals after 2005 as the PbR system was rolled out, probably because hospitals now had a financial incentive to record them. Some PCTs, which bore the cost of additional referrals, reacted by requiring that the referral had to be routed via the patient's GP. The introduction of 18 week waiting time targets in 2008 measured from date of referral to admission may also have increased referrals and available appointments.

Figure 4 plots practice mean C&B rate for 2006-2009 against practice mean non-attendance rate for 2003-5 before the national roll out of C&B. Practices with higher non-attendance rates in 2003-2005, before the national roll out of C&B, have significantly lower use of C&B in 2006-2009, suggesting that it is important to allow for unobservable practice characteristics when attempting to estimate the effect of C&B on non-attendance.

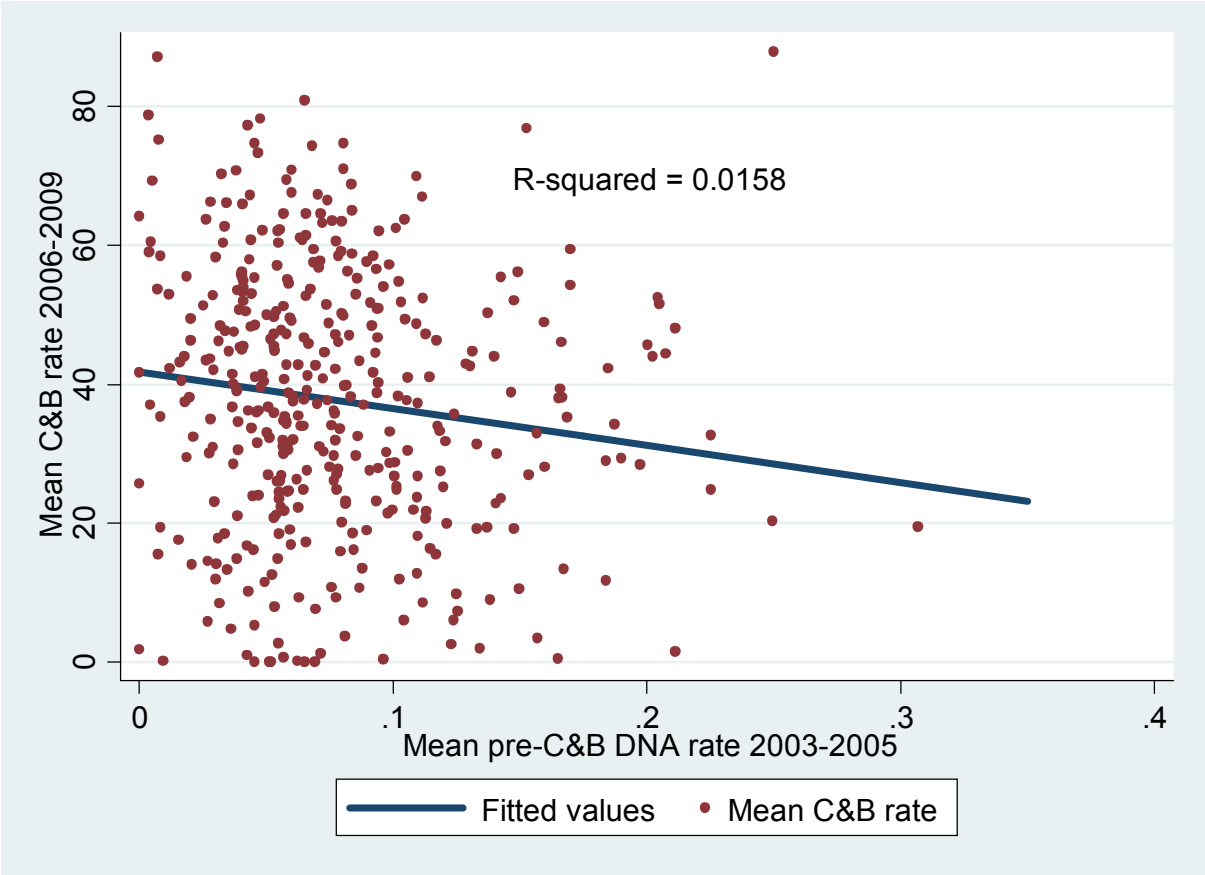

Figure 4. Practice mean C&B rate 2006-2009 and mean practice non-attendance rate for 2003-2005.

Notes. The figure plots points from the 100 practices at the centiles of the distribution of pre-C&B non attendance rates. The line is the regression of practice mean C&B rate for 2006-2009 on practice mean non-attendance rate for 2003-5 for 7974 practices (2003-4 rates for pilot C&B practices): $C\&Brate_{j06\text{-}9} = 41.77$ (SE=0.42) $-53.38 * n_{j03\text{-}05}$ (SE = 4.79), $R^2 = 0.016$.

5.2 Estimated effects of C&B

Table 3 presents results from the fixed effects Poisson model (8). The reported coefficients are the estimated proportionate change in the outcomes from a one unit (i.e. 1%) increase in the C&B rate. Since the national average C&B rate had increased from zero in 2004 to nearly 50% in 2009 we also report the percentage change in the outcome rates from a 50% increase in the C&B rate: $\Delta\%_{50}$C&B = $100[\exp(50\beta_1) - 1]$.

Table 3. Models of general practice non-attendance, patient cancellation, attendance, and hospital cancellation rates.

	Non-attendance	GP referrals	Patient cancellation	Hospital cancellations
C&B rate	-0.0023	-0.0006	-0.0009	0.0068
	[0.00012]***	[0.000071]***	[0.00034]*	[0.00044]***
Observations	46690	46692	46493	45711
GP practices	8263	8264	8207	8054
AIC	338484.9	942532.7	483806.5	407773.3
BIC	339780.1	943827.9	485101	409065.4
$\Delta\%_{50}$ C&B rate	-10.877	-3.020	-4.237	40.156
Std. Error	[0.554]***	[0.344]***	[1.610]**	[3.105]***
95% CI	[-11.964, -9.791]	[-3.694, -2.347]	[-7.392, -1.081]	[34.071, 46.241]

Notes. Estimates from Poisson models with practice fixed effects. All models also contain year and SHA interactions, total practice list size, proportion of list in 13 age/gender groups, patients per whole time equivalent GP, average GP age, proportion female GPs, proportion GPs qualified in UK, proportion of non-principal GPs, 15 QOF practice quality indicators, disease prevalence and patient deprivation, proportion of referrals to 53 separate specialities. Full results are in Appendix Table A2. Coefficients are the proportionate change in the dependent variable from a one unit (1%) change in the C&B rate. $\Delta\%_{50}$CB rate = $100[\exp(\beta_1 50) - 1]$ is the percentage change in the outcome rate due to a 50% increase in the C&B rate. Robust standard errors in square brackets allow for clustering within GP practices.
* significant at 5%; ** significant at 1% ; *** significant at 0.1%

An increase in use of C&B within a GP practice is associated with a decrease in patient non-attendance at first scheduled outpatient appointment. A 50 percentage point increase in C&B utilisation is associated with a –10.9% (95% CI: –9.8%, – 12.0%) proportionate reduction in the rate of non-attendance. Increased use of C&B is also associated with a reduction in the practice referral rate, though the proportionate reduction (-3%) with a 50% increase in the C&B rate is smaller, but significant in absolute terms due to higher rate of referral. Patient cancellations are also reduced in practices with higher C&B uptake rates. Finally, hospital cancellations are much higher when the practice C&B rate is higher: a 50% increase in the C&B rate is associated with a 40% proportionate increase in the hospital cancellation rate.

Table 4 has the results from the specification (9) in which the effect of C&B is allowed to vary across years. We report both the coefficients on the C&B rate for each year and the estimated effect of C&B in each year as $\Delta\%\text{C\&B}_t = 100[\exp(\beta_{1t}(B_t/R_t)) - 1]$. The marginal proportional effect (β_{1t}) on non-attendance in participating practices is largest in 2005, but less precisely estimated than in subsequent years, probably because of the smaller number (2,228) of practices using C&B for a selected number of specialties in this pilot year. Given the low rates of C&B uptake (0.8%) and small number of practices using C&B in 2005 the total national effect $\Delta\%\text{C\&B}t$ is smallest in 2005 (-0.3%) but increases in absolute magnitude to -11.8% by 2009.

Table 4. Models of general practice non-attendance, patient cancellation, attendance, and hospital cancellation rates: time varying association with C&B rate

	Non-attendance	GP referrals	Patient cancellation	Hospital cancellations
C&B rate 2005	-0.0035	-0.00196	0.0125	0.0287
	[0.0014]*	[0.00075]**	[0.005]*	[0.0045]***
C&B rate 2006	-0.0010	-0.00106	-0.0025	0.0084
	[0.0002]***	[0.00010]***	[0.0005]***	[0.0006]***
C&B rate 2007	-0.0020	-0.00076	-0.0019	0.0082
	[0.0001]***	[0.00008]***	[0.0004]***	[0.0006]***
C&B rate 2008	-0.0030	-0.00055	0.0002	0.0063
	[0.0002]***	[0.00009]***	[0.0004]	[0.0005]***
C&B rate 2009	-0.0025	-0.00029	-0.0003	0.0051
	[0.0002]***	[0.00011]**	[0.0005]	[0.0006]***
Observations	46690	46692	46493	45711
GP practices	8263	8264	8207	8054
AIC	338174	941715.9	483087.4	406923.3
BIC	339504.2	943046.1	484416.9	408250.3
$\Delta\%C\&B_{2005}$	-0.261	-0.146	0.938	2.154
SE	[0.107]*	[0.056]**	[0.374]*	[0 .337]**
95% CI	[-0.471, -0.051]	[-0.256, -0.036]	[0.205, 1.671]	[1.493, 2.81]
$\Delta\%C\&B_{2006}$	-1.823	-2.019	-4.622	0.207
SE	[-5.08]***	[0.187]***	[0.851]***	[5.54]***
95% CI	[-2.526, -1.120]	[-2.385, -1.654]	[-6.290, -2.953]	[0.134, 0.281]
$\Delta\%C\&B_{2007}$	-7.420	-2.863	-7.165	17.278
SE	[0.494]***	[0.304]***	[1.273]***	[1.448]***
95% CI	[-8.388, -6.452]	[-3.459, -2.267]	[-9.659, -4.671]	[14.440, 20.116]
$\Delta\%C\&B_{2008}$	-12.793	-2.483	1.104	33.331
SE	[0.634]***	[0.377]***	[1.912]	[3.139]***
95% CI	[-14.036, -11.549]	[-3.221, -1.744]	[-2.740, 4.757]	[30.205, 44.105]
$\Delta\%C\&B_{2009}$	-11.794	-1.434	-1.569	28.650
SE	[0.813]***	[0.523]*	[2.389]	[3.964]***
95% CI	[-13.388 , -10.201]	[-2.458, -0.410]	[-6.236, 3.128]	[20.880, 36.419]

Notes. Estimates from Poisson models with practice fixed effects. All models also contain year and SHA interactions, total practice list size, proportion of list in 13 age/gender groups, patients per whole time equivalent GP, average GP age, proportion female GPs, proportion GPs qualified in UK, proportion of non-principal GPs, 15 QOF practice quality indicators, disease prevalence and patient deprivation, proportion of referrals to 53 separate specialities. Coefficients are the proportionate change in the dependent variable from a one unit change in the explanatory. $\Delta\%C\&B_t = 100[\exp(\beta_{1t}(B_t/R_t)) - 1]$ is the percentage change in rates in year *t* relative to 2004 due to C&B, where B_t/R_t is the national average C&B rate in year *t*. Robust standard errors in square brackets allow for clustering within GP practices.
* significant at 5%; ** significant at 1%, *** significant at 0.1%

The changes in the coefficient on the C&B rate over time do not provide much evidence to suggest that the changes in Choice policy in 2006 and 2008 widening choice sets changed the effect of C&B uptake. The C&B uptake coefficient in the referral model became steadily less negative over the period and followed no clear trend in the non-attendance model.

The proportional reduction in the GP referral rate for participating practices declined over time but nationally this was more than offset by increasing use of C&B, so that by 2009 we estimate that C&B reduced referral rates by -1.4% (95% CI: -2.5%, -0.4%) Patients of practices using C&B had higher rates of hospital cancellations. The proportionate effect was largest in the first year of C&B, but it declined sharply over time, suggesting that initially hospitals found it more difficult to handle referrals made by the C&B system.

C&B increased the proportion of appointments cancelled by patients in some years and reduced it in other years. The marginal effects were statistically significant at 5% in only two of five years. C&B made it easier to cancel a booked appointment but also provided more information at the time of booking and patients with a better estimate of the costs and benefits of attendance at time of booking may be more likely to attend and hence less likely to cancel.

Figure 5 shows the national impact of the introduction of C&B on non-attendance rates from 2005 to 2009 estimated from the model (9) which allows for differential C&B effects in each time period. The red line plots the percentage difference between the average non-attendance rate in year t and the average non-attendance rate in 2004 before the introduction of C&B. The black dashed line plots the equivalent counterfactual difference with a zero C&B rate in all years. By 2007 the reduction in the national non-attendance rate due to C&B was over 7% and this had increased to over 12% by 2009.

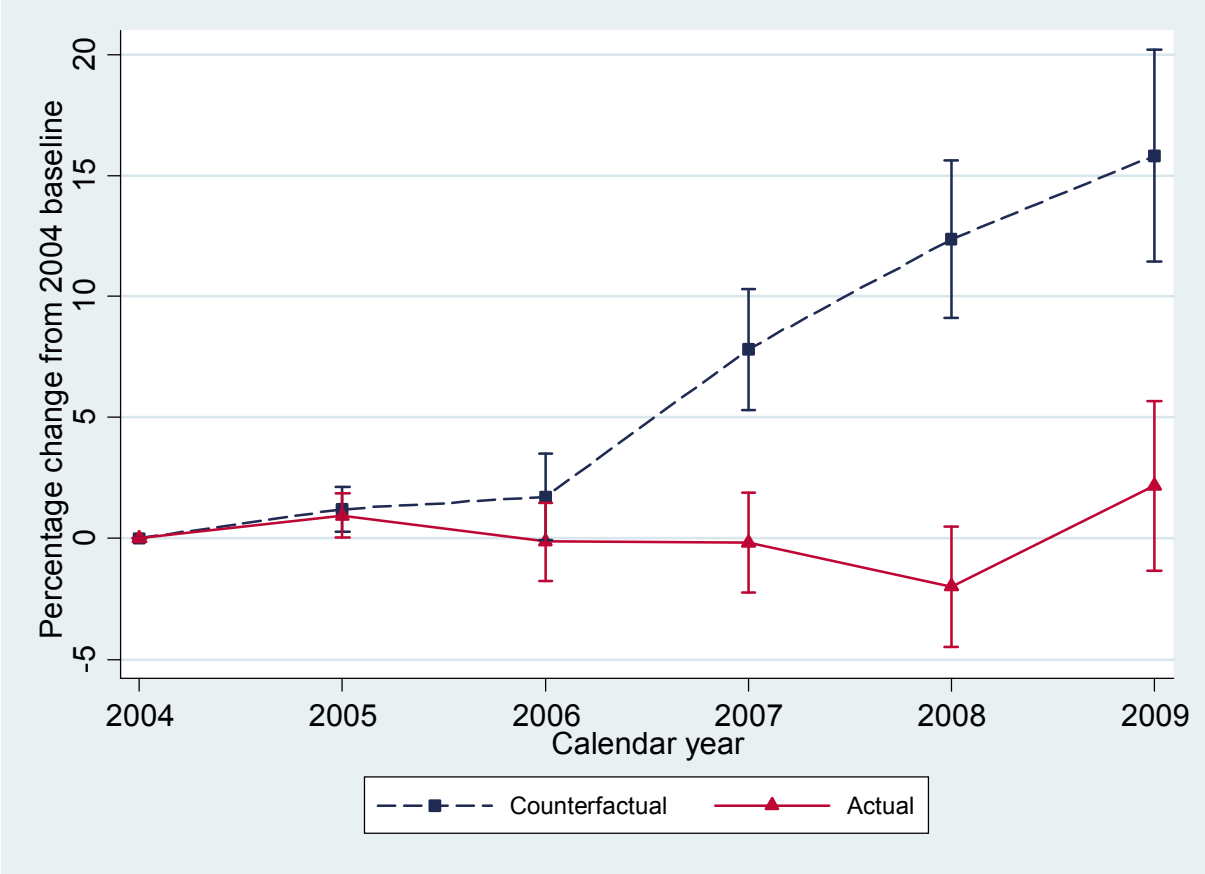

Figure 5: National impact of C&B on patient Non-attendance. Relative trends in non-attendance rates across GP practices with and without the introduction of C&B (2005 onwards)

Notes. The denominator for the non-attendance rate is total referrals minus hospital cancellations. Non-attendance is non-attendance without notice. The solid red line uses results from the model in Table 4 and plots the estimated percentage difference between the non-attendance rate in year *t* and 2004 as $\exp\left(\hat{\beta}_{1t}(B_t / R_t) + \sum_j w_{jt}\hat{\beta}_{3jt}\right) - 1$ where B_t/R_t is the national average C&B rate in year t, w_{jt} is the proportion of practices in SHA j in year t, and $\hat{\beta}_{3jt}$ is the estimated region j effect in year t. The dashed black line plots the counterfactual percentage difference between year t and 2004 with a zero C&B rate in all years as $\exp\left(\sum_j w_{jt}\hat{\beta}_{3jt}\right) - 1$.

Analogously, Figure 6 shows the impact of C&B on referrals with the difference between the counterfactual change from 2004 with no C&B in any year (black dashed line) and actual change from 2004 (red line). The percentage change due to C&B was around 3% by 2006 and this remained fairly steady over time.

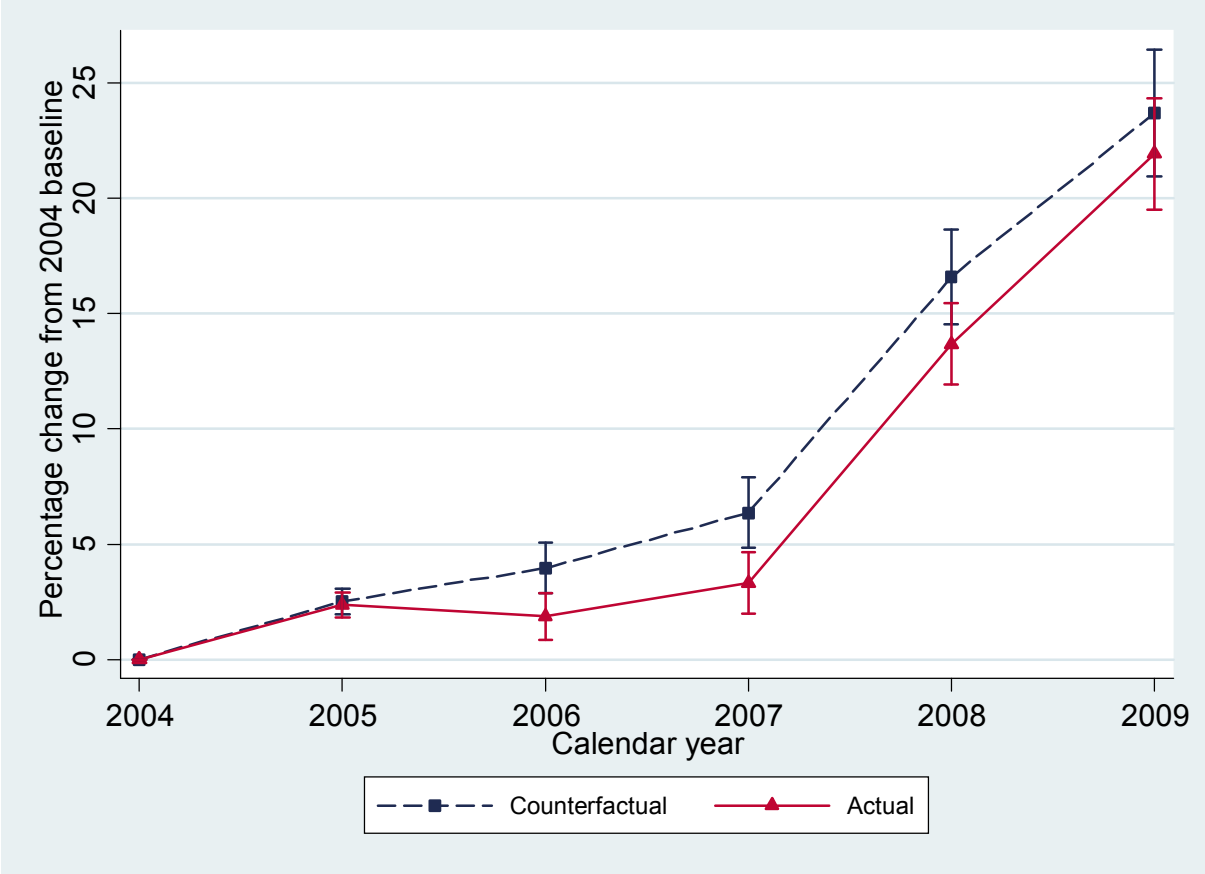

Figure 6: National impact of C&B on GP referrals. Comparison of relative changes in referrals with and without the introduction of C&B in 2005.

Notes. The denominator is the practice list. The solid red line uses results from the model in Table 4 and plots the estimated percentage difference between the referral rate in year t and 2004 as $\exp\left(\hat{\beta}_{1t}(B_t / R_t) + \sum_j w_{jt}\hat{\beta}_{3jt}\right) - 1$ where B_t/R_t is the national average C&B rate in year t, w_{jt} is the proportion of practices in SHA j in year t, and $\hat{\beta}_{3jt}$ is the estimated region j effect in year t. The dashed black line plots the counterfactual percentage difference between year t and 2004 with a zero C&B rate in all years as $\exp\left(\sum_j w_{jt}\hat{\beta}_{3jt}\right) - 1$.

Table 5 has results from specification (10) in which the effect of C&B is allowed to vary across the 10 SHA regions. It reports both the estimated coefficients β_{1j} and the estimated national effects in each region in 2009 as $\Delta\%\text{C\&B}_j = 100[\exp(\beta_{1j}(B_{2009}/R_{2009})) - 1$. The marginal percentage effect of C&B (β_{1j}) on non-attendance was greatest in the West Midlands and smallest in the South West. Estimated relative effects of C&B on non-attendance were negative across all 10 regions, but not statistically significant in the South West, which had the largest uptake of C&B along with East Midlands (over 64%), with the later associated with a -14.6% reduction in non-attendance. The West Midlands and South Central regions experienced the largest relative reductions in non-attendance of -18.6% and -15.5% respectively. There were more varied impacts on referral rates across the SHAs. Although the national average effect was negative (see Tables 3 and 4) there was a significant (at 5%) negative effect only in 6 of the 10 SHAs and in two of the SHAs (North East and London) the effect was positive, though insignificant. There were also mixed effects on patient cancellations across the SHAs: patient cancellations increased significantly as a result of C&B in 2 of the SHAs and decreased significantly in three of them. Interestingly, in the South West, the region with the highest uptake of C&B, non-attendance decreased slightly by only -3.9%, but referral rates

were reduced by over -5% and patient cancellations by -61.9%. Hospital cancellations increased in all SHAs.

Table 5. Models of general practice non-attendance, patient cancellation, attendance, and hospital cancellation rates: region varying association with C&B rate

	Non-attendance	GP referrals	Patient cancellation	Hospital cancellations
C&B rate NE	-0.0019	0.00008	-0.0011	0.0073
	[0.0004]***	[0.00019]	[0.0012]	[0.0017]***
C&B rate NW	-0.0018	-0.00081	0.0053	0.0153
	[0.0004]***	[0.00018]**	[0.0010]***	[0.0013]***
C&B rate YO	-0.0016	0.00003	-0.0004	0.0075
	[0.0003]***	[0.00018]	[0.0013]	[0.001851]***
C&B rate EM	-0.0025	-0.00067	0.0020	0.0072
	[0.0004]***	[0.00024]**	[0.0006]**	[0.0008]***
C&B rate WM	-0.0044	-0.00125	0.0006	0.0080
	[0.0004]***	[0.00019]**	[0.0021]	[0.0020]***
C&B rate W	-0.0028	-0.00019	0.0004	0.0090
	[0.0005]***	[0.0002]	[0.0006]	[0.0011]***
C&B rate LO	-0.0017	-0.00105	-0.0027	0.0024
	[0.0003]***	[0.00022]**	[0.0005]***	[0.0006]***
C&B rate SE	-0.0023	-0.00025	-0.0053	0.0036
	[0.0004]***	[0.00035]	[0.0018]**	[0.0017]*
C&B rate SC	-0.0043	-0.00047	0.0017	0.0097
	[0.0004]***	[0.00021]*	[0.0014]	[0.0020]***
C&B rate SW	-0.0006	-0.00088	-0.0145	0.0031
	[0.0004]	[0.00023]**	[0.0018]***	[0.0025]
Observations	46690	46692	46493	45711
GP practices	8263	8264	8207	8054
AIC	338008	941360	479690	405764
BIC	339382	942734	481063	407134
$\Delta\%C\&B_{NE}$	-9.838	0.429	-6.152	49.332
SE	[2.052]***	[1.036]	[6.134]	[14.342]***
95% CI	[-13.860, -5.815]	[-1.603, 2.460]	[-18.174, 5.870]	[21.222, 77.442]
$\Delta\%C\&B_{NW}$	-9.452	-4.289	33.555	130.786
SE	[1.935]***	[0.978]**	[7.496]***	[16.590]***
95% CI	[-13.245, -5.659]	[-6.161, -2.418]	[18.864, 48.247]	[98.271, 163.302]
$\Delta\%C\&B_{YO}$	-8.248	-0.183	-2.076	49.030
SE	[1.449]***	[-0.19]	[7.034]	[14.698]***
95% CI	[-11.087, -5.409]	[-2.099, 1.733]	[-15.863, 11.711]	[20.223, 77.837]
$\Delta\%C\&B_{EM}$	-14.586	-4.218	13.473	58.827
SE	[2.038]***	[-2.89]**	[4.394]**	[7.707]***
95% CI	[-18.581, -10.591]	[-7.414, -4.025]	[4.861, 22.086]	[43.722, 73.932]
$\Delta\%C\&B_{WM}$	-18.637	-5.719	2.635	45.709
SE	[1.516]***	[0.865]**	[10.336]	[13.395]***
95% CI	[-21.608, -15.666]	[-7.414, -4.025]	[-17.622, 22.893]	[19.456, 71.962]
$\Delta\%C\&B_{E}$	-12.206	-0.893	1.961	52.703

SE	[2.254]***	[1.094]	[2.735]	[7.723]***
95% CI	[-16.623, -7.789]	[-3.038, 1.252]	[-3.399, 7.321]	[37.567, 67.839]
Δ%C&B$_{LO}$	-5.962	-3.785	-9.422	9.416
SE	[1.631]***	[0.793]**	[1.667]***	[2.402]***
95% CI	[-12.880, -6.487]	[-5.339, -2.232]	[-12.689, -6.154]	[4.709, 14.124]
Δ%C&B$_{SE}$	-9.684	-1.119	-21.035	17.347
SE	[1.796]***	[1.544]	[6.273]**	[9.010]
95% CI	[-14.245, -7.206]	[-4.145, 1.908]	[-33.330, -8.740]	[-0.312, 35.007]
Δ%C&B$_{SC}$	-15.490	-1.824	6.772	46.092
SE	[1.391]***	[0.793]**	[5.967]	[11.351]***
95% CI	[-18.217, -12.763]	[-3.378, -0.269]	[-4.923, 18.467]	[23.844, 68.340]
Δ%C&B$_{SW}$	-3.862	-5.706	-61.879	23.366
SE	[2.881]	[1.451]**	[4.537]***	[20.588]
95% CI	[-9.508, 1.784]	[-8.550, -2.863]	[-70.772, -52.987]	[-16.986, 63.719]

Notes. Estimates from Poisson models with practice fixed effects. SHA key (SHA C&B rate in 2009): NE = North East (0.55), NW – North West (0.54), YO = Yorkshire (0.54), EM = East Midlands (0.64), WM = West Midlands (0.47)), E = East of England (0.47, LO = London (0.37), SE = South East (0.45), SC = South Central (0.39), SW = South West (0.67). All models also contain year and SHA interactions, total practice list size, proportion of list in 13 age/gender groups, patients per whole time equivalent GP, average GP age, proportion female GPs, proportion GPs qualified in UK, proportion of non-principal GPs, 15 QOF practice quality indicators, disease prevalence and patient deprivation, proportion of referrals to 53 separate specialities. Coefficients are the proportionate change in the dependent variable from a one unit change in the explanatory. $\Delta\%\text{C\&B}_j = 100[\exp(\beta_{1j}(B_{j2009}/R_{j2009})) - 1]$ is the percentage change in rates in SHA j in 2009 relative to 2004 due to C&B. Robust standard errors allow for clustering within GP practices.
* significant at 5%; ** significant at 1%, *** significant at 0.1%

Table 6 has results from robustness checks in which we vary the estimation method (across columns) and the model specification (rows within blocks). Results are qualitatively robust across the estimation methods. The Poisson random effects model, which includes the prior year 2003 outcome as an explanatory, is closest to our preferred Poisson fixed effects model, with very similar coefficients and smaller standard errors. The conditional fixed effects negative binomial, which again includes 2003 outcome as an explanatory, yields smaller effects. The population averaged negative binomial has bigger effects except for hospital cancellations where the effect is negative, though small and insignificant, rather than positive as with the other estimators. The Poisson random effects and negative binomial population averaged models also show that the variance exceeds the mean so that it is necessary to allow for over dispersion in computing the standard errors. We do so by using robust standard errors clustered on practices.

Table 6. Models of general practice non-attendance, patient cancellation, attendance, and hospital cancellation rates: robustness checks

Dependent variable	Parameter	Poisson FE	Poisson RE	Negbin FE	Negbin PA
Non-attendance	C&B Rate	-0.0023	-0.0024	-0.0020	-0.0030
		[0.0001]***	[0.0001]***	[0.0001]***	[0.0001]***
	Alpha		0.0722		0.0984
			[0.0013]***		[0.0027]***
With Hospital cancellations	C&B Rate	-0.0025			
		[0.0001]***			
With GP referrals	C&B Rate	-0.0022			
		[0.0001]***			
	GP ref	0.0263			
		[0.0049]***			
With baseline*year interactions	C&B Rate	-0.0024			
		[0.0001]***			
GP referrals	C&B Rate	-0.0006	-0.0006	-0.0005	-0.0013
		[0.00007]***	[0.00001]***	[0.00005]***	[0.00009]***
	Alpha		0.0331		0.0370
			[0.0005]***		[0.0006]***
With baseline*year interactions	C&B Rate	-0.0006			
		[0.0001]***			
Patient Cancellation	C&B Rate	-0.0009	-0.0009	-0.0004	-0.0057
		[0.0004]*	[0.0001]***	[0.0002]	[0.0005]***
	Alpha		0.9278		1.0801
			[0.0134]***		[0.0139]***
With Hospital cancellations	C&B Rate	-0.0012			
		[0.0003]***			
With GP referrals	C&B Rate	-0.0007			
		[0.0003]*			
	GP ref	0.0913			
		[0.01050]***			
With baseline*year interactions	C&B Rate	-0.0006			
		[0.0003]*			
Hospital Cancellation	C&B Rate	0.0068	0.0066	0.0041	-0.0002
		[0.0004]***	[0.0001]***	[0.0004]***	[0.0005]
	Alpha		1.238481		1.4411
			[0.0179]***		[0.0187]***
With baseline*year interactions	C&B Rate	0.0084			
		[0.0004]***			

Notes. Alpha – overdispersion parameter in Poisson RE and Negbin PA (population averaged estimator i.e. pooled cross-sectional Negative Binomial with robust and clustered standard errors). All models also contain year and SHA interactions, total practice list size, proportion of list in 13 age/gender groups, patients per whole time equivalent GP, average GP age, proportion female GPs, proportion GPs qualified in UK, proportion of non-principal GPs, 15 QOF practice quality indicators, disease prevalence and patient deprivation, proportion of referrals to 53 separate specialities. Baseline-Year interaction models also include the outcome rate for the prior year 2003 interacted with the year dummies. Reported coefficients are proportionate changes from 1% point increase in C&B rate. * significant at 5%; ** significant at 1%, *** significant at 0.1%

Using all referrals, rather than referrals net of hospital cancellations leads to only a small change in the C&B coefficient in the model for patient non-attendance. It leads to a larger and more precisely estimated negative coefficient in the model for patient cancellations, suggesting that C&B may have led to some substitution from patient to hospital initiated cancellations.

We also estimated models for non-attendance and patient cancellations which included the GP referral rate as an explanatory variable. The coefficient on the C&B rate then shows the effect of increasing the number of appointments booked via the C&B system with the number of referrals held constant. The coefficients on the C&B rate are very similar to those for our preferred specification for non-attendance. The coefficient on the referral rate in the non-attendance rate model is positive which is as expected from the theoretical model in section 2: a reduction in the referral threshold (increase in referral rate) implies that on average patients with lower benefits from referral are now being referred and they are more likely to not attend.

The final model in each block adds the interaction of the outcome in year 2003 with the year dummies and so allows for time varying effects of unobserved practice characteristics correlated with the baseline year 2003 outcome. The estimated effects of C&B are very similar to those in our preferred specification.

6 Discussion

The electronic Choose and Book system for general practice referrals to hospital outpatient departments was introduced in 2005. We investigated its effects using models with practice fixed effects, year by region effects, and a large set of time varying covariates, including practice and patient characteristics and the mix of outpatient specialities, for over 7700 English practices from 2004 to 2009. We find that practices which increased their use of the C&B system experienced a reduction in the proportion of referred patients failing to attend. They also reduced their referral rates. The results are robust to alternative estimation methods which allow for time invariant practice heterogeneity by including the baseline 2003 level of the outcomes as an explanatory. The finding that the non-attendance rate and the referral rate both declined is also consistent with our theoretical model which explained why referrals and non-attendance are likely to move in the same direction. If C&B raised the cost to the GP of making bookings this would increase the threshold level of patient benefit needed for a referral and the referral rate would decrease. As a consequence patients who are referred are more likely to have higher benefit from attending and so the non-attendance rate will also fall.

The estimated magnitudes of the C&B effects on non-attendance are similar to the effects of other policies designed to reduce patient non-attendance. A meta-analysis of randomised controlled trials of Short Messaging Service (SMS) text message reminders in the days prior to scheduled first appointments found an estimated improvement in the odds ratio of attending of 1.48 (Guy et al, 2011). Given the 2009 attendance rate of 84.57% this implies an increase in the attendance rate of 4.45 percentage points to 89.1 %. The non-attendance and cancellation rates in 2009 were 6.36% and 5.32% respectively. A 50% increase in C&B utilisation was associated with a -10.88% decrease in non-attendance to 5.67%, and a -4.24% reduction in cancellations to 5.09%, which is equivalent to a 0.92 percentage point increase in the attendance rate. This is smaller than the effect found for SMS interventions in a randomised controlled trial setting, where compliance with the intervention was likely to be close to 100% (C&B with 100% compliance would increase attendance by 1.75 percentage points).

We do not have the data to attempt a cost-benefit analysis of C&B but the magnitudes of the estimated effects of the introduction of C&B are likely to be economically significant. Patients failed to attend 738,948 first GP outpatient appointments out of 11,624,090 first referrals recording non-attendance in 2009. C&B was used to make 50% of the appointments in this year and we estimate that in the absence of C&B there would have been 85,594 (15.8%) more non-attended appointments and 358,449 (3%) more referrals. About 30% of first GP referrals do not result in hospital admissions, tests or onward referral to another consultant. This suggests that some of the referrals not made as a result of C&B may have been medically unnecessary, especially as these marginal referrals would have been those perceived by the patient and GP to be of low net benefit. The increase in hospital cancellations would have increased the administrative costs. Over 90% of hospital cancelled appointments are rescheduled so that hospital cancellations are less likely to result in patients not being seen, but patients could be delayed as a result or their appointment cancellations or could have made unnecessary visits to the hospital.

Our results demonstrate that there was a marked change in referral rates and in the rates of patient non-attendance once referred associated with changes in use of C&B within practices over time. We interpret this as the effect of the use of the C&B electronic booking system. An alternative interpretation is that the coefficient also picks up the extent to which C&B is a proxy for practices propensity to offer patients a wider choice of provider following the national change in Choice policy in 2006 and 2008. We think that our inclusion of practice fixed effects, year by region effects, and a large set of time varying practice level covariates supports our interpretation of the C&B coefficient

as a causal effect. But, in either case, we have shown that changes in factors within the decision making process over referrals and attendance have an economically important effects on attendance and referrals. Given the concern about welfare loss from non-attended appointments with proposals to introduce patient charges for missed appointments (Watt, 2015), this study suggests there is scope for further reducing non-attendance by expanding the use of electronic booking systems and facilitating patient choice in referral decisions to improve the appropriateness of referrals.

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Online Appendix

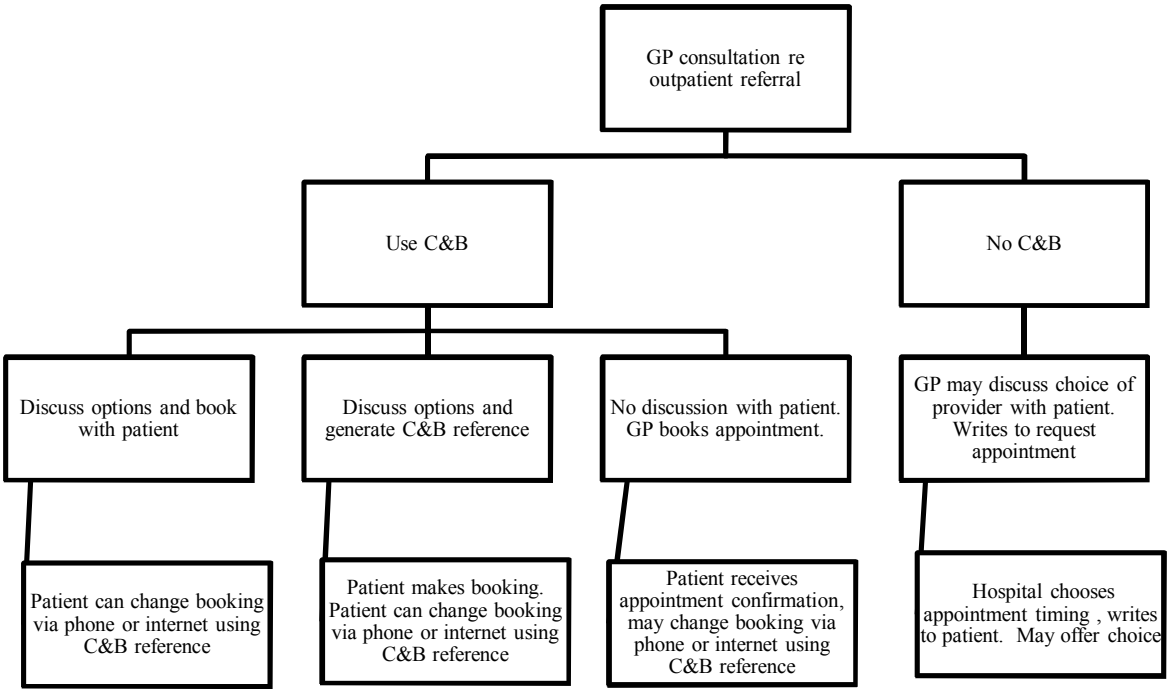

Figure A1. Outpatient referral process with and without the use of Choose and Book.

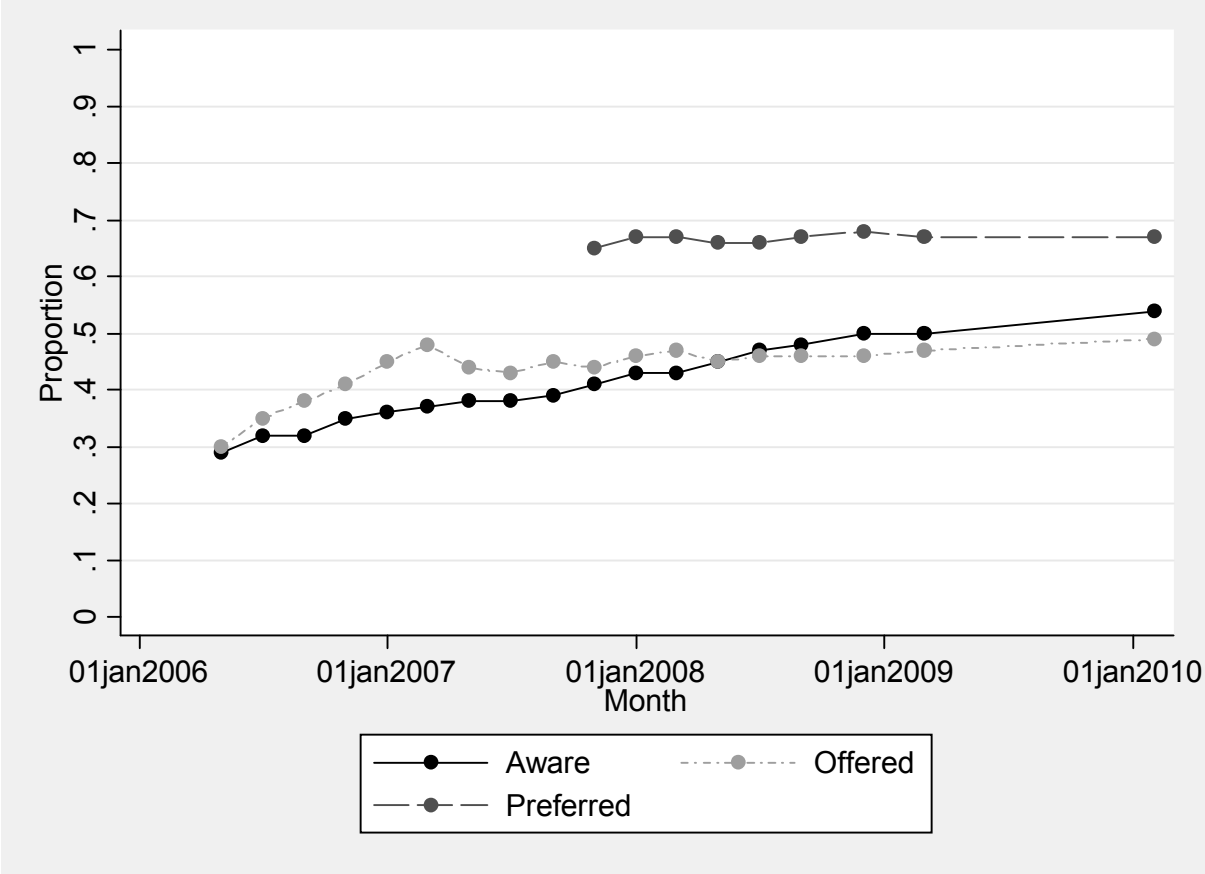

Figure A2. Trends in availability, awareness and preferences for choice of outpatient appointment in England (2006 – 2010).

Note: Responses to the National Patient Choice Survey (Dixon, 2010) from samples of patients with a first GP referral to specialist outpatient appointment. Patienets asked if offered choice of hospital for first appointment, were aware of choice of fist appointment, and whether they preferred to have a choice.

Table A1. Summary statistics on covariates 2004-2009

Practice demographics	Mean	SD	Min	Max
Proportion of males aged 0 to 4	0.029	0.009	0.000	0.116
Proportion of males aged 5 to 14	0.061	0.013	0.000	0.162
Proportion of males aged 15 to 45	0.221	0.050	0.090	0.722
Proportion of males aged 45 to 64	0.126	0.023	0.001	0.328
Proportion of males aged 65 to 74	0.039	0.012	0.000	0.104
Proportion of males aged 75 to 84	0.022	0.009	0.000	0.084
Proportion of males aged 85 and over	0.006	0.003	0.000	0.040
Proportion of females aged 0 to 4	0.028	0.008	0.000	0.098
Proportion of females aged 5 to 14	0.058	0.013	0.000	0.148
Proportion of females aged 15 to 44	0.208	0.038	0.078	0.551
Proportion of females aged 45 to 64	0.118	0.026	0.000	0.195
Proportion of females aged 65 to 74	0.041	0.013	0.000	0.115
Proportion of females aged 75 to 84	0.030	0.012	0.000	0.132
Proportion of females aged 85 and over	0.013	0.007	0.000	0.192
Total practice list size	6555	3959	501	39919
GPs				
Listsize per WTE GP	1868	761	26	28067
GMS practice	0.402	0.490	0.000	1.000
Proportion of non principle GPs	0.171	0.218	0.000	1.000
Proportion of female GPs	0.376	0.277	0.000	1.000
Average age of GP in practice	48.08	7.66	28	75
Proportion of UK qualified GPs	0.68	0.38	0	1
Deprivation and prevalence				
Moving average LISI score	0.175	0.050	0.001	0.50
Proportion claiming incapacity benefit & severe disability allowance	12.20	8.15	0.13	90
Chronic disease smoking prevalence	0.056	0.027	0.002	0.21
Coronary Heart Disease Prevalence	0.168	0.063	0	1
Stroke or Transient Ischaemic Attacks (TIA) Prevalence	0.035	0.013	0	0.149
Hypertension Prevalence	0.016	0.007	0	0.185
Cancer Prevalence	0.126	0.035	0	0.513
Mental Health Prevalence	0.010	0.005	0	0.044
Asthma Prevalence	0.007	0.005	0	0.305
Hyperthyroidism prevalence	0.058	0.014	0	0.224
Epilepsy prevalence	0.025	0.009	0	0.106
Practice QOF indicators				
Blood pressure age 45 recorded 80%	0.913	0.281	0	1
Cervical smear auditing	0.965	0.183	0	1
Child development checks	0.952	0.214	0	1
Practice provides support to stop smoking	0.989	0.104	0	1
Review of patient complaints	0.959	0.199	0	1
Significant event reviews > 12	0.900	0.301	0	1
Nurse development plans	0.939	0.240	0	1
Non-clinical staff appraisal	0.942	0.233	0	1
Ante-natal care and screening plan	0.993	0.086	0	1

Prescribing advice and action	0.928	0.259	0	1
Patient consultations last 10 minutes	0.973	0.162	0	1
Computer back up	0.988	0.111	0	1
Morning and afternoon appointments 5 days per week	0.988	0.111	0	1
Up to date clinical summaries 80%	0.821	0.384	0	1
Cervical screening population achievement rates	0.771	0.083	0	1
Referral specialties				
General surgery	8.992	4.462	0	50
Urology	4.060	1.427	0	50
Breast surgery	1.751	1.871	0	34.028
Colorectal surgery	0.801	1.356	0	22.222
Surgery GI	0.170	0.491	0	12.500
Vascular surgery	0.616	0.863	0	20.732
Trauma & orthopaedics	10.190	3.604	0	66.667
ENT	8.380	2.383	0	50
Ophthalmology	9.189	3.194	0	100
Oral surgery	1.051	1.195	0	33.333
Restorotive dentistry	0.187	0.456	0	20
Maxillo-facial surgery	0.208	0.485	0	9.524
Neurosurgery	0.313	0.454	0	14.286
Plastic surgery	1.175	1.404	0	66.667
Cardiothoracic surgery	0.053	0.304	0	25
Paediatric surgery	3.620	1.912	0	100
A&E	0.055	0.269	0	8.333
Anaesthetics	0.724	0.785	0	100
General medicine	4.221	3.887	0	35.714
Gastroenterology	2.128	1.613	0	17.442
Endocrinology	0.602	0.829	0	13.294
Clinical haematology	0.781	0.616	0	12.644
Hepatology	0.077	0.271	0	30.275
Diabetic medicine	0.496	1.185	0	38.207
Audiological medicine	0.514	1.109	0	12.590
Immunology and allergy	0.164	0.287	0	10
Rehabilitation	0.200	1.141	0	29.389
Palliative medicine	0.022	0.121	0	10
Allergy	0.091	0.224	0	6.383
Cardiology	4.065	2.409	0	39.538
Anticoagulant service	0.059	0.232	0	10.753
Dermatology	7.373	2.838	0	62.500
Thoracic medicine	1.397	1.426	0	33.220
Infectious diseases	0.098	0.351	0	17.436
Genito-urinary medicine	0.439	0.520	0	28.571
Nuclear Medicine	0.238	2.233	0	84.949
Neurology	2.483	1.094	0	23.810
Rheumatology	2.389	1.653	0	50
Paediatrics	0.511	1.136	0	33.333

Geriatric medicine	0.939	0.927	0	25
Medical ophthalmology	0.042	0.301	0	9.319
Obstetrics	5.569	4.516	0	83.333
Gynaecology	9.237	2.978	0	100
Midwife episode	1.210	2.713	0	41.067
Physiotherapy	0.860	2.805	0	32.795
Podiatry	0.134	0.636	0	12.743
Dietetics	0.085	0.360	0	11.739
Orthoptics	0.058	0.243	0	4.884
Adult mental illness	0.816	1.565	0	80
Child and adolescent psychiatry	0.139	0.352	0	20
Old age psychiatry	0.465	1.038	0	63.768
Clinical oncology	0.355	1.253	0	34.093
General pathology	0.210	0.851	0	50

Notes. Number of practice year observations: 47,302. LISI score: proportion of prescriptions dispensed without charge on grounds of low income.

Table A2. Models of general practice non-attendance, patient cancellation, attendance, and hospital cancellation rates. Full results.

	Non-attendance	GP referrals	Patient cancellation	Hospital cancellations
C&B rate	-0.0023	-0.000613	-0.00087	0.0068
	-19.167	-8.634	-2.559	15.455
2005.year#1.sha_NE	.	.	.	.
	0	0	0	0
2005.year#2.sha_NW	-0.0023	-0.000613	-0.00087	0.0068
	8.676	8.739	5.554	8.889
2005.year#3.sha_YO	-0.0023	-0.000613	-0.00087	0.0068
	4.827	6.423	-4.209	-0.652
2005.year#4.sha_EM	-0.0023	-0.000613	-0.00087	0.0068
	8.711	12.740	3.369	3.534
2005.year#5.sha_WM	-0.0023	-0.000613	-0.00087	0.0068
	-7.840	1.080	-4.332	5.060
2005.year#6.sha_E	-0.0023	-0.000613	-0.00087	0.0068
	-4.861	-0.186	-5.699	2.957
2005.year#7.sha_LO	-0.0023	-0.000613	-0.00087	0.0068
	-5.321	-1.279	-0.250	3.669
2005.year#8.sha_SE	-0.0023	-0.000613	-0.00087	0.0068
	-1.389	-4.329	-0.880	10.578
2005.year#9.sha_SC	-0.0023	-0.000613	-0.00087	0.0068
	0.306	6.406	11.202	-1.368
2005.year#10.sha_SW	-0.0023	-0.000613	-0.00087	0.0068
	6.135	6.679	1.161	-0.946
2006.year#1.sha_NE	-0.0023	-0.000613	-0.00087	0.0068
	0.850	3.066	-0.952	2.641
2006.year#2.sha_NW	-0.0023	-0.000613	-0.00087	0.0068
	11.287	12.849	7.029	9.132
2006.year#3.sha_YO	-0.0023	-0.000613	-0.00087	0.0068
	8.902	-1.993	-2.200	-7.751
2006.year#4.sha_EM	-0.0023	-0.000613	-0.00087	0.0068
	8.166	9.533	5.859	6.180
2006.year#5.sha_WM	-0.0023	-0.000613	-0.00087	0.0068
	-2.177	5.222	-4.684	6.055
2006.year#6.sha_E	-0.0023	-0.000613	-0.00087	0.0068
	-0.655	0.529	2.056	1.760
2006.year#7.sha_LO	-0.0023	-0.000613	-0.00087	0.0068
	-7.925	-1.876	-1.120	4.233
2006.year#8.sha_SE	-0.0023	-0.000613	-0.00087	0.0068
	-0.055	-4.502	-3.175	7.015
2006.year#9.sha_SC	-0.0023	-0.000613	-0.00087	0.0068
	2.110	11.211	13.052	-0.487
2006.year#10.sha_SW	-0.0023	-0.000613	-0.00087	0.0068

	6.372	9.971	5.643	-1.254
2007.year#1.sha_NE	-0.0023	-0.000613	-0.00087	0.0068
	9.297	0.236	-2.735	6.914
2007.year#2.sha_NW	-0.0023	-0.000613	-0.00087	0.0068
	11.541	15.214	5.355	8.629
2007.year#3.sha_YO	-0.0023	-0.000613	-0.00087	0.0068
	8.049	-0.591	-3.444	-1.620
2007.year#4.sha_EM	-0.0023	-0.000613	-0.00087	0.0068
	11.302	9.570	1.667	11.248
2007.year#5.sha_WM	-0.0023	-0.000613	-0.00087	0.0068
	4.314	11.180	-1.084	6.756
2007.year#6.sha_E	-0.0023	-0.000613	-0.00087	0.0068
	5.976	2.576	-0.667	6.803
2007.year#7.sha_LO	-0.0023	-0.000613	-0.00087	0.0068
	-10.025	-0.990	0.363	5.326
2007.year#8.sha_SE	-0.0023	-0.000613	-0.00087	0.0068
	-0.717	-4.350	-2.315	6.778
2007.year#9.sha_SC	-0.0023	-0.000613	-0.00087	0.0068
	4.030	5.817	3.721	-0.919
2007.year#10.sha_SW	-0.0023	-0.000613	-0.00087	0.0068
	7.378	14.551	8.670	-0.650
2008.year#1.sha_NE	-0.0023	-0.000613	-0.00087	0.0068
	4.780	1.376	-1.859	12.078
2008.year#2.sha_NW	-0.0023	-0.000613	-0.00087	0.0068
	13.758	17.498	7.715	18.081
2008.year#3.sha_YO	-0.0023	-0.000613	-0.00087	0.0068
	3.826	-0.266	-5.225	6.064
2008.year#4.sha_EM	-0.0023	-0.000613	-0.00087	0.0068
	8.518	8.576	-1.940	18.475
2008.year#5.sha_WM	-0.0023	-0.000613	-0.00087	0.0068
	5.246	13.471	-1.657	10.873
2008.year#6.sha_E	-0.0023	-0.000613	-0.00087	0.0068
	9.438	4.804	-2.254	15.322
2008.year#7.sha_LO	-0.0023	-0.000613	-0.00087	0.0068
	-8.180	-0.344	-0.632	14.715
2008.year#8.sha_SE	-0.0023	-0.000613	-0.00087	0.0068
	-2.267	-0.125	-4.752	13.030
2008.year#9.sha_SC	-0.0023	-0.000613	-0.00087	0.0068
	-3.387	9.920	7.568	5.868
2008.year#10.sha_SW	-0.0023	-0.000613	-0.00087	0.0068
	5.508	14.020	7.463	10.607
2009.year#1.sha_NE	-0.0023	-0.000613	-0.00087	0.0068
	5.124	2.902	-0.236	13.284
2009.year#2.sha_NW	-0.0023	-0.000613	-0.00087	0.0068
	14.605	15.051	10.856	19.757
2009.year#3.sha_YO	-0.0023	-0.000613	-0.00087	0.0068

	4.193	-0.539	-3.772	9.344
2009.year#4.sha_EM	-0.0023	-0.000613	-0.00087	0.0068
	8.336	11.057	1.782	18.146
2009.year#5.sha_WM	-0.0023	-0.000613	-0.00087	0.0068
	4.694	15.324	0.215	16.373
2009.year#6.sha_E	-0.0023	-0.000613	-0.00087	0.0068
	10.939	4.793	1.957	18.473
2009.year#7.sha_LO	-0.0023	-0.000613	-0.00087	0.0068
	-6.257	0.131	1.013	18.884
2009.year#8.sha_SE	-0.0023	-0.000613	-0.00087	0.0068
	-2.203	7.072	1.558	14.833
2009.year#9.sha_SC	-0.0023	-0.000613	-0.00087	0.0068
	2.778	10.230	7.118	10.800
2009.year#10.sha_SW	-0.0023	-0.000613	-0.00087	0.0068
	8.444	14.264	9.443	16.937
Proportion of males aged 0 to 4	-0.0023	-0.000613	-0.00087	0.0068
	0.455	1.615	-1.046	3.179
Proportion of males aged 5 to 14	-0.0023	-0.000613	-0.00087	0.0068
	-1.381	3.010	1.073	1.278
Proportion of males aged 15 to 44	-0.0023	-0.000613	-0.00087	0.0068
	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Proportion of males aged 45 to 64	-0.0023	-0.000613	-0.00087	0.0068
	-1.335	0.642	-0.488	2.920
Proportion of males aged 65 to 74	-0.0023	-0.000613	-0.00087	0.0068
	-0.184	-0.036	-2.287	3.351
Proportion of males aged 75 to 84	-0.0023	-0.000613	-0.00087	0.0068
	1.021	-1.607	-2.950	2.314
Proportion of males aged 85 and over	-0.0023	-0.000613	-0.00087	0.0068
	0.458	-2.466	-0.841	-0.261
Proportion of females aged 0 to 4	-0.0023	-0.000613	-0.00087	0.0068
	2.176	1.359	-0.374	3.943
Proportion of females aged 5 to 14	-0.0023	-0.000613	-0.00087	0.0068
	-1.872	1.551	0.906	0.545
Proportion of females aged 15 to 44	-0.0023	-0.000613	-0.00087	0.0068
	-1.041	2.498	-2.448	2.416
Proportion of females aged 45 to 64	-0.0023	-0.000613	-0.00087	0.0068
	0.000	3.331	1.527	2.101
Proportion of females aged 65 to 74	-0.0023	-0.000613	-0.00087	0.0068

	-2.566	-1.550	-2.202	0.277
Proportion of females aged 75 to 84	-0.0023	-0.000613	-0.00087	0.0068
	-1.159	1.631	-0.048	1.399
Proportion of females aged 85 and over	-0.0023	-0.000613	-0.00087	0.0068
	-0.454	1.338	-0.169	4.112
Total practice list size	-0.0023	-0.000613	-0.00087	0.0068
	-0.148	-0.055	1.229	-7.875
Listsize per WTE GP	-0.0023	-0.000613	-0.00087	0.0068
	2.594	1.455	2.821	-1.155
GMS practice	-0.0023	-0.000613	-0.00087	0.0068
	-1.795	-3.440	-3.544	-0.780
Proportion of non principle GPs	-0.0023	-0.000613	-0.00087	0.0068
	-1.144	0.000	3.422	-1.200
Proportion of female GPs	-0.0023	-0.000613	-0.00087	0.0068
	-0.273	-0.595	-0.963	3.466
Average age of GP in practice	-0.0023	-0.000613	-0.00087	0.0068
	-1.609	2.019	1.457	-4.708
Proportion of UK qualified GPs	-0.0023	-0.000613	-0.00087	0.0068
	1.645	3.141	2.031	0.314
Moving average LISI score	-0.0023	-0.000613	-0.00087	0.0068
	3.970	-0.372	1.037	1.699
Proportion claiming incapacity benefit & severe disability allowance	-0.0023	-0.000613	-0.00087	0.0068
	-4.666	2.767	1.824	1.317
Chronic disease smoking prevalence	-0.0023	-0.000613	-0.00087	0.0068
	-2.596	-1.359	2.118	-0.564
Coronary Heart Disease Prevalence	-0.0023	-0.000613	-0.00087	0.0068
	-2.029	1.272	1.030	3.154
Stroke or Transient Ischaemic Attacks (TIA) Prevalence	-0.0023	-0.000613	-0.00087	0.0068
	1.681	0.647	-0.629	0.519
Hypertension Prevalence	-0.0023	-0.000613	-0.00087	0.0068
	0.409	-2.203	-1.447	1.413
Cancer Prevalence	-0.0023	-0.000613	-0.00087	0.0068
	2.746	-6.723	-3.091	4.514
Mental Health Prevalence	-0.0023	-0.000613	-0.00087	0.0068
	-1.161	2.515	3.336	2.087
Asthma Prevalence	-0.0023	-0.000613	-0.00087	0.0068
	-0.727	-1.229	-1.561	3.455
Hyperthyroidism	-0.0023	-0.000613	-0.00087	0.0068

prevalence				
	-3.608	3.958	0.559	-1.980
Epilepsy prevalence	-0.0023	-0.000613	-0.00087	0.0068
	3.006	-0.742	-0.407	-0.678
Blood pressure age 45 recorded 80%	-0.0023	-0.000613	-0.00087	0.0068
	0.544	-0.472	1.290	1.756
Cervical smear auditing	-0.0023	-0.000613	-0.00087	0.0068
	1.346	0.678	1.189	0.962
Child development checks	-0.0023	-0.000613	-0.00087	0.0068
	-1.055	2.103	0.098	0.000
Practice provides support to stop smoking	-0.0023	-0.000613	-0.00087	0.0068
	0.535	-1.498	-1.077	0.841
Review of patient complaints	-0.0023	-0.000613	-0.00087	0.0068
	2.394	0.848	0.329	0.952
Significant event reviews > 12	-0.0023	-0.000613	-0.00087	0.0068
	2.364	1.646	1.366	0.000
Nurse development plans	-0.0023	-0.000613	-0.00087	0.0068
	-0.513	0.701	0.830	0.000
Non-clinical staff appraisal	-0.0023	-0.000613	-0.00087	0.0068
	0.000	-1.216	0.000	0.000
Ante-natal care and screening plan	-0.0023	-0.000613	-0.00087	0.0068
	-0.646	0.000	1.118	0.914
Prescribing advice and action	-0.0023	-0.000613	-0.00087	0.0068
	-2.089	-0.603	1.926	-1.071
Patient consultations last 10 minutes	-0.0023	-0.000613	-0.00087	0.0068
	-0.488	0.879	2.055	-0.870
Computer back up	-0.0023	-0.000613	-0.00087	0.0068
	-1.209	-0.716	-0.888	0.000
Morning and afternoon appointments 5 days per week	-0.0023	-0.000613	-0.00087	0.0068
	-1.663	1.352	-0.786	-0.838
Up to date clinical summaries 80%	-0.0023	-0.000613	-0.00087	0.0068
	0.450	-1.691	0.881	-0.763
Cervical screening population achievement rates	-0.0023	-0.000613	-0.00087	0.0068
	-1.422	0.996	-1.417	0.851
General surgery	-0.0023	-0.000613	-0.00087	0.0068
	2.221	0.696	10.048	-1.992
Urology	-0.0023	-0.000613	-0.00087	0.0068

	2.232	-0.602	8.853	1.171
Breast surgery	-0.0023	-0.000613	-0.00087	0.0068
	-1.167	0.876	8.139	-2.879
Colorectal surgery	-0.0023	-0.000613	-0.00087	0.0068
	3.895	7.416	8.693	1.066
Surgery GI	-0.0023	-0.000613	-0.00087	0.0068
	-2.537	-0.692	2.570	1.820
Vascular surgery	-0.0023	-0.000613	-0.00087	0.0068
	-1.382	-0.090	6.554	0.000
Trauma & orthopaedics	-0.0023	-0.000613	-0.00087	0.0068
	-0.438	-0.439	10.010	2.654
ENT	-0.0023	-0.000613	-0.00087	0.0068
	3.845	0.629	6.125	0.000
Ophthalmology	-0.0023	-0.000613	-0.00087	0.0068
	0.000	3.393	11.564	-4.994
Oral surgery	-0.0023	-0.000613	-0.00087	0.0068
	5.043	-5.630	-9.720	-3.539
Restorotive dentistry	-0.0023	-0.000613	-0.00087	0.0068
	-1.197	-6.133	-6.871	-1.017
Maxillo-facial surgery	-0.0023	-0.000613	-0.00087	0.0068
	2.760	7.027	4.898	3.279
Neurosurgery	-0.0023	-0.000613	-0.00087	0.0068
	-0.897	-2.318	-4.028	-3.058
Plastic surgery	-0.0023	-0.000613	-0.00087	0.0068
	2.579	-5.013	3.434	-0.509
Cardiothoracic surgery	-0.0023	-0.000613	-0.00087	0.0068
	1.502	2.784	-5.271	0.000
Paediatric surgery	-0.0023	-0.000613	-0.00087	0.0068
	3.492	0.574	5.230	1.145
A&E	-0.0023	-0.000613	-0.00087	0.0068
	0.000	-0.159	-6.189	2.292
Anaesthetics	-0.0023	-0.000613	-0.00087	0.0068
	2.622	8.897	11.867	2.791
General medicine	-0.0023	-0.000613	-0.00087	0.0068
	6.410	6.177	11.584	1.996
Gastroenterology	-0.0023	-0.000613	-0.00087	0.0068
	0.000	6.545	12.184	3.521
Endocrinology	-0.0023	-0.000613	-0.00087	0.0068
	1.739	7.144	7.750	0.000
Clinical haematology	-0.0023	-0.000613	-0.00087	0.0068
	0.278	-3.733	-1.851	4.564
Hepatology	-0.0023	-0.000613	-0.00087	0.0068
	-3.189	6.175	11.594	-0.342
Diabetic medicine	-0.0023	-0.000613	-0.00087	0.0068
	10.765	-1.136	5.232	6.915
Audiological medicine	-0.0023	-0.000613	-0.00087	0.0068

	6.706	7.744	12.256	1.972
Immunology and allergy	-0.0023	-0.000613	-0.00087	0.0068
	1.328	2.988	7.617	-5.026
Rehabilitation	-0.0023	-0.000613	-0.00087	0.0068
	0.375	0.550	9.427	6.407
Palliative medicine	-0.0023	-0.000613	-0.00087	0.0068
	4.768	-1.748	-4.180	-2.147
Allergy	-0.0023	-0.000613	-0.00087	0.0068
	-4.722	-1.831	3.206	1.947
Cardiology	-0.0023	-0.000613	-0.00087	0.0068
	-1.346	-0.218	7.523	1.927
Anticoagulant service	-0.0023	-0.000613	-0.00087	0.0068
	-1.435	0.344	2.447	-3.234
Dermatology	-0.0023	-0.000613	-0.00087	0.0068
	-0.853	-0.428	7.217	4.394
Thoracic medicine	-0.0023	-0.000613	-0.00087	0.0068
	5.673	0.219	6.440	1.695
Infectious diseases	-0.0023	-0.000613	-0.00087	0.0068
	2.280	-1.500	2.443	-1.811
Genito-urinary medicine	-0.0023	-0.000613	-0.00087	0.0068
	3.623	5.009	8.684	-1.377
Nuclear Medicine	-0.0023	-0.000613	-0.00087	0.0068
	-3.922	5.496	10.066	6.527
Neurology	-0.0023	-0.000613	-0.00087	0.0068
	2.773	-4.308	-0.196	-0.926
Rheumatology	-0.0023	-0.000613	-0.00087	0.0068
	7.251	-0.347	6.623	4.317
Paediatrics	-0.0023	-0.000613	-0.00087	0.0068
	0.732	11.768	12.542	-5.580
Geriatric medicine	-0.0023	-0.000613	-0.00087	0.0068
	0.867	1.264	1.145	4.941
Medical ophthalmology	-0.0023	-0.000613	-0.00087	0.0068
	1.631	6.014	6.033	3.816
Obstetrics	-0.0023	-0.000613	-0.00087	0.0068
	-0.902	-4.232	5.181	-0.666
Gynaecology	-0.0023	-0.000613	-0.00087	0.0068
	0.441	0.000	7.913	-3.987
Midwife episode	-0.0023	-0.000613	-0.00087	0.0068
	1.305	2.069	10.657	2.639
Physiotherapy	-0.0023	-0.000613	-0.00087	0.0068
	3.761	1.523	11.981	5.181
Podiatry	-0.0023	-0.000613	-0.00087	0.0068
	-1.366	-0.428	4.685	3.143
Dietetics	-0.0023	-0.000613	-0.00087	0.0068
	-0.691	1.350	2.717	4.197
Orthoptics	-0.0023	-0.000613	-0.00087	0.0068

	1.927	13.800	4.966	4.835
Adult mental illness	-0.0023	-0.000613	-0.00087	0.0068
	-0.358	6.687	13.426	-4.196
Child and adolescent psychiatry	-0.0023	-0.000613	-0.00087	0.0068
	4.486	1.376	0.946	-3.050
Old age psychiatry	-0.0023	-0.000613	-0.00087	0.0068
	2.823	-6.999	-1.071	0.000
Clinical oncology	-0.0023	-0.000613	-0.00087	0.0068
	0.000	-2.132	2.770	8.578
General pathology	.	.	.	.
Observations	46690	46692	46493	45711
GP practices	8263	8264	8207	8054
AIC	338484.9	942532.7	483806.5	407773.3
BIC	339780.1	943827.9	485101	409065.4

Notes. Estimates from Poisson models with practice fixed effects. All models also contain year and SHA interactions, total practice list size, proportion of list in 13 age/gender groups, patients per whole time equivalent GP, average GP age, proportion female GPs, proportion GPs qualified in UK, proportion of non-principal GPs, 15 QOF practice quality indicators, proportion of referrals to 53 separate specialities. Coefficients are the proportionate change in the dependent variable from a one unit (1%) change in the C&B rate. Robust standard errors in square brackets allow for clustering within GP practices. SHA key: NE = North East, NW – North West, YO = Yorkshire, EM = East Midlands, WM = West Midlands, E = East of England, LO = London, SE = South East, SC = South Central, SW = South West.
z stats in second row for each variable: 1.65, p: 0.010; 1.96, p: 0.05; 2.58, p: 0.01, 3.30, p: 0.001.

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