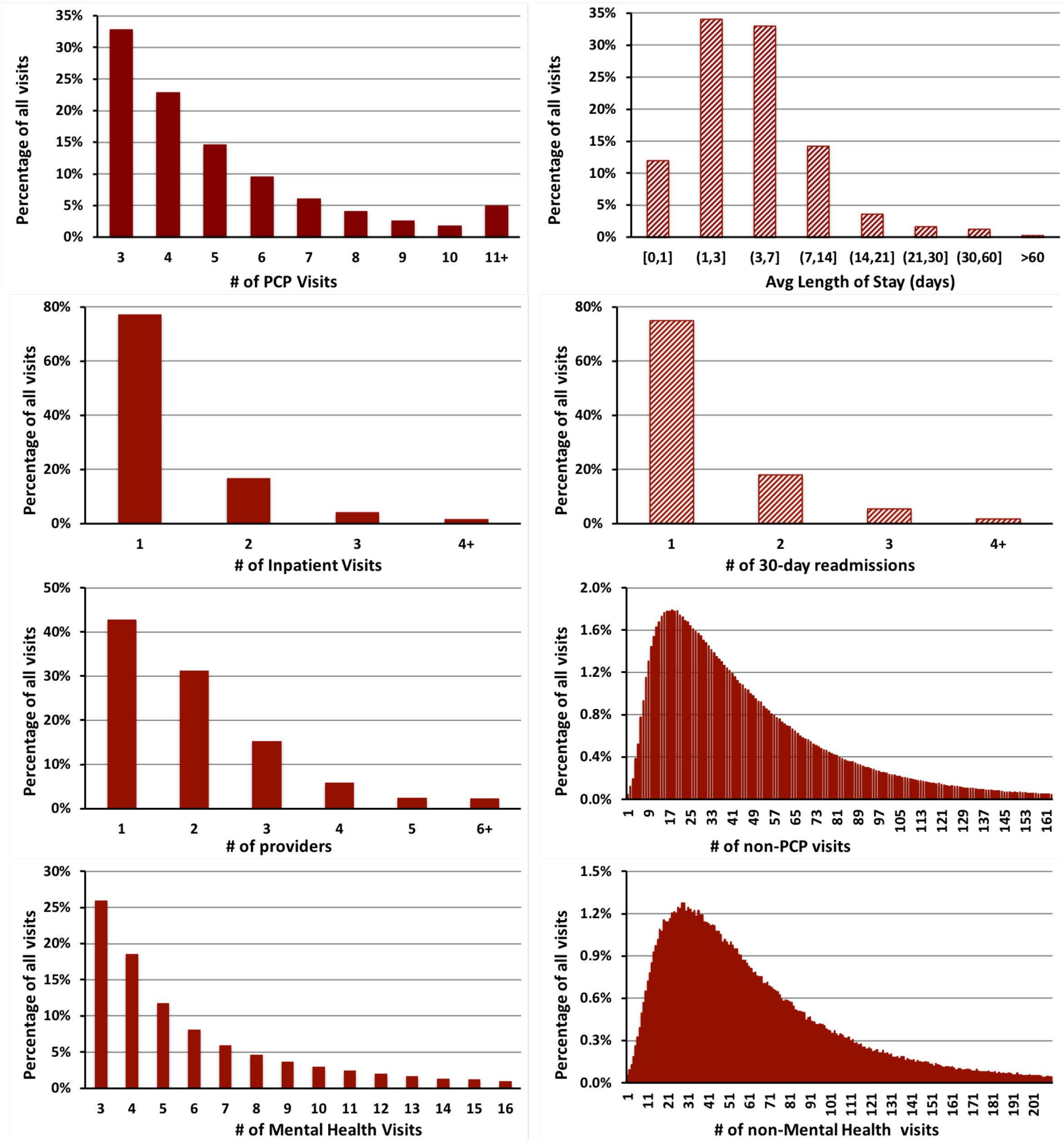
Online Appendix for "Maintaining Continuity in Service: An Empirical Examination of Primary Care Physicians"

Appendix A.1. Raw PCMDOC Data: Distribution of Key Variables



Notes: The plot of non-PCP visits and non-Mental health visits include only those visits that constitute at least 0.5% of all visits. The plot of Mental health visits include only those visits that constitute at least 1% of all visits. The plot of inpatient visits and 30-day readmissions include those observations where we observed at least 1 outcome.

Appendix A.2. Robustness Checks

We perform multiple robustness checks, described below. Table A1 reports the estimates (of CCI and CCI^2 only) from the full test of H1. Our conclusions continue to hold.

(1) **Threshold on PCP visits**. To ensure that the restriction of at least 3 PCP visits does not introduce bias, we test separate specifications where the threshold of annual PCP visits is 1 and 2.

(2) **Restricting to "healthier" population.** We restrict the data to the least sick patients, those with a baseline Charlson comorbidity index of 5, to alleviate concerns that the sickest patients are the main driver of our result.

(3) **Restricting to "Medicare ineligible" patients.** A limitation of our data is that we do not have records on prescriptions or services that veterans may have obtained from outside of the VA, Medicare in particular. While Medicare eligibility provides veterans with increased choice, access, and flexibility, the continuity and coordination of care may suffer. Consequently, we limit the data to only those observations where a patient is under 65 years of age, and is thus, ineligible for Medicare.

(4) **Restricting to patients who do not move.** One of the drivers of care fragmentation may be due to relocation of veterans. In particular, veterans who are considered "snowbirds", those with multiple or seasonal residences throughout the year, may utilize services from different providers in different regions/VA facilities, leading to their care being potentially fragmented (Al-Haque et al. 2015). To address this, we restrict our data to only those observations where the patient's reported residence (based on their home zip code) has not changed for the entire previous year.

(5) **CCI calculation.** To analyze the sensitivity of our choice of number of periods (past 4 quarters) to calculate CCI, we test alternate specifications where we use past 3 and 5 quarters separately to calculate CCI.

(6) **Fixed effects for PCP visits.** A potential concern could be that all the variation in CCI is coming from patients who frequently visit PCPs. Thus, instead of controlling for *PCP_ Visits* using a continuous and linear effect, we include a fixed effect for *PCP_ Visits*, where we limit the number of PCP visits to 11 (that constitutes almost 97% of all visits). A key finding is that each PCP visit is (positively) correlated with the outcomes (see Table A2).

(7) **No roll-over of periods.** The calculation of CCI on a rolling four-quarter basis might induce some "autocorrelation" bias. Thus, we run a specification, where there is a no overlap of periods for CCI calculation. In other words, we only consider every 4 periods, starting with the first period when the patient enters the cohort. This effectively reduces the number of observations by approximately three-fourths.

(8) **Restricting to CCI values where there are multiple PCP visits.** As described in §3.5.2, there is a certain range of CCI values ($CCI \in ((0, 0.2], (0.8, 0.9]))$ that is dominated by a large number of PCP visits, which may introduce bias in our results. Consequently, we run a specification where we exclude observations with CCI values in this range.

(9) **Including facility fixed effects.** While we extensively control for patient demographics and risk factors, we have included relatively fewer controls for patient's primary care facility. There may be other unobservable characteristics that are unique to each facility, for example, physician practice styles, that

Table A1 Estimates from robustness checks.

		LOG (IP_VISITS)	*LOG (MEAN_LOS)*	*LOG (30D_READ)*	*LOG (IP_VISITS)*	*LOG (MEAN_LOS)*	*LOG (30D_READ)*	Obs.
(1a)	*CCI*	-0.0401***	-0.0481***	-0.0111***	-0.2303***	-0.2605***	-0.0865***	3,452,192
		(0.0065)	(0.0080)	(0.0020)	(0.0429)	(0.0507)	(0.0162)	
	CCI^2				0.1361***	0.1519***	0.0539***	
					(0.0280)	(0.0330)	(0.0108)	
(1b)	*CCI*	-0.0355***	-0.0430***	-0.0097***	-0.1668***	-0.1851***	-0.0677***	2,911,705
		(0.0065)	(0.0079)	(0.0019)	(0.0429)	(0.0507)	(0.0161)	
	CCI^2				0.0939**	0.1016**	0.0415***	
					(0.0279)	(0.0330)	(0.0108)	
(2)	*CCI*	-0.0291***	-0.0346***	-0.0098***	-0.1083*	-0.1324*	-0.0523**	910,431
		(0.0068)	(0.0084)	(0.0023)	(0.0430)	(0.0508)	(0.0188)	
	CCI^2				0.0574*	0.0709*	0.0308*	
					(0.0288)	(0.0342)	(0.0129)	
(3)	*CCI*	-0.0497***	-0.0595***	-0.0154*	-0.1846*	-0.2117*	-0.0638	314,878
		(0.0137)	(0.0168)	(0.0064)	(0.0766)	(0.0936)	(0.0393)	
	CCI^2				0.1000+	0.1128+	0.0359	
					(0.0552)	(0.0679)	(0.0280)	
(4)	*CCI*	-0.0286***	-0.0335***	-0.0061*	-0.1124*	-0.1211*	-0.0363*	1,840,873
		(0.0075)	(0.0091)	(0.0024)	(0.0453)	(0.0544)	(0.0173)	
	CCI^2				0.0609*	0.0637+	0.0220+	
					(0.0298)	(0.0359)	(0.0118)	
(5a)	*CCI*	-0.0301***	-0.0349***	-0.0079**	-0.2296***	-0.2693***	-0.0900***	2,046,859
		(0.0071)	(0.0087)	(0.0024)	(0.0474)	(0.0554)	(0.0199)	
	CCI^2				0.1425***	0.1673***	0.0586***	
					(0.0307)	(0.0358)	(0.0134)	
(5b)	*CCI*	-0.0333***	-0.0391***	-0.0084***	-0.1397***	-0.1537**	-0.0621***	2,046,859
		(0.0075)	(0.0092)	(0.0024)	(0.0389)	(0.0462)	(0.0149)	
	CCI^2				0.0792**	0.0852**	0.0400***	
					(0.0259)	(0.0309)	(0.0103)	
(6)	*CCI*	-0.0286***	-0.0346***	-0.0081***	-0.0707+	-0.0889+	-0.0249+	1,976,384
		(0.0071)	(0.0088)	(0.0023)	(0.0380)	(0.0458)	(0.0147)	
	CCI^2				0.0305	0.0393	0.0121	
					(0.0248)	(0.0301)	(0.0098)	
(7)	*CCI*	-0.0370***	-0.0465***	-0.0099**	-0.1291**	-0.1534*	-0.0656*	560,287
		(0.0098)	(0.0120)	(0.0038)	(0.0494)	(0.0610)	(0.0256)	
	CCI^2				0.0672*	0.0780+	0.0406*	
					(0.0332)	(0.0411)	(0.0179)	
(8)	*CCI*	-0.0371***	-0.0449***	-0.0101***	-0.1648***	-0.1897***	-0.0569***	3,399,046
		(0.0062)	(0.0076)	(0.0019)	(0.0374)	(0.0451)	(0.0153)	
	CCI^2				0.0904***	0.1024***	0.0330**	
					(0.0241)	(0.0292)	(0.0101)	
(9)	*CCI*	-0.0255***	-0.0303***	-0.0063**	-0.1058**	-0.1157**	-0.0409**	2,054,404
		(0.0060)	(0.0075)	(0.0021)	(0.0329)	(0.0405)	(0.0141)	
	CCI^2				0.0584**	0.0621*	0.0252*	
					(0.0218)	(0.0270)	(0.0097)	
(10)	*CCI*	-0.0327***	-0.0387***	-0.0086***	-0.1274**	-0.1425**	-0.0509**	2,053,489
		(0.0073)	(0.0090)	(0.0023)	(0.0415)	(0.0493)	(0.0156)	
	CCI^2				0.0691*	0.0758*	0.0309**	
					(0.0273)	(0.0326)	(0.0106)	
(11)	*CCI*	-0.0313***	-0.0370***	-0.0083***	-0.1299**	-0.1457**	-0.0511**	2,054,404
		(0.0072)	(0.0089)	(0.0023)	(0.0406)	(0.0482)	(0.0156)	
	CCI^2				0.0719**	0.0793*	0.0312**	
					(0.0267)	(0.0318)	(0.0105)	

Notes: We only report the coefficient on *CCI*. Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. +p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001.

Table A2 Association between CCI and patient outcomes: Fixed effects for PCP visits.

	LOG (IP_ VISITS)	*LOG (MEAN_ LOS)*	*LOG (30D_ READ)*
PCP_ VISITS=4	0.0124***	0.0162***	0.0005
	(0.0025)	(0.0030)	(0.0011)
PCP_ VISITS=5	0.0339***	0.0431***	0.0040**
	(0.0037)	(0.0046)	(0.0015)
PCP_ VISITS=6	0.0521***	0.0641***	0.0091***
	(0.0049)	(0.0059)	(0.0024)
PCP_ VISITS=7	0.0712***	0.0875***	0.0145***
	(0.0065)	(0.0079)	(0.0029)
PCP_ VISITS=8	0.0781***	0.0969***	0.0107***
	(0.0074)	(0.0090)	(0.0028)
PCP_ VISITS=9	0.1030***	0.1218***	0.0234***
	(0.0094)	(0.0112)	(0.0040)
PCP_ VISITS=10	0.1013***	0.1219***	0.0151**
	(0.0107)	(0.0130)	(0.0049)
PCP_ VISITS=11	0.1140***	0.1329***	0.0341***
	(0.0147)	(0.0182)	(0.0067)
Observations	1,976,384	1,976,384	1,976,384
R-squared	0.1545	0.1502	0.0610

Notes: Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

may introduce bias in our estimates. To address this concern, we run a specification where we include facility fixed effects.

(10) **Using the Charlson score as a continuous variable.** To address the concern that using the Charlson score as a categorical variable may introduce some bias in our result, we run a specification where we treat it as a continuous variable but log-transform it, due to its distribution (see Appendix A.1).

(11) **Including the Charlson score for every period.** Clinical literature typically uses the Charlson score at baseline to control for a patient's baseline risk of experiencing any adverse outcomes. However, there may be a concern that the patient's risk may drastically change over time due to unobservable factors. To address this, we calculate the Charlson score for every period (quarter).

Finally, we perform two additional checks where we replace the key independent variable of interest (CCI) with an alternate measure in the regression model specification in §4.1. We find that our conclusions continue to hold, as described below.

Using Number of Providers Visited. We use the number of providers that a patient sees in the prior year (*N_ PROVID*) as the main independent variable of interest; however, we log-transform the variable given its distribution (see Appendix A.1). We note that *N_ PROVID*, along with *PCP_ VISITS*, is used to derive CCI (see §3.2). The OLS estimates (see Table A3, left panel) reveal that *LOG(N_ PROVID)* is positively correlated with the outcomes, which is not surprising since CCI is inversely proportional to *N_ PROVID*. In other words, controlling for the total number of PCP visits, the more providers a patient sees, the worse his outcomes are. We then include a quadratic term, $LOG(N\_PROVID)^2$ and find evidence of curvilinearity (Table A3, right panel); the threshold values (where the outcomes are minimized) for *IP_ VISITS* and *30D_ READ* are 1.23 visits and 1.45 visits, respectively.

Table A3 Association between number of providers seen and patient outcomes

	LOG (IP_VISITS)	*LOG (MEAN_LOS)*	*LOG (30D_READ)*	*LOG (IP_VISITS)*	*LOG (MEAN_LOS)*	*LOG (30D_READ)*
LOG (N_PROVID)	0.0251***	0.0296***	0.0073***	-0.0114+	-0.0096	-0.0096***
	(0.0044)	(0.0054)	(0.0014)	(0.0065)	(0.0076)	(0.0028)
LOG (N_PROVID)^2				0.0277***	0.0298***	0.0128***
				(0.0060)	(0.0069)	(0.0024)
LOG (PCP_VISITS)	0.0700***	0.0848***	0.0160***	0.0643***	0.0786***	0.0134***
	(0.0076)	(0.0091)	(0.0027)	(0.0080)	(0.0095)	(0.0027)
REST_VISITS	0.0027***	0.0032***	0.0008***	0.0027***	0.0032***	0.0008***
	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)

Notes: Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. +p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001.

In addition, we test a specification where, instead of controlling for *N_PROVID* using a (log-transformed) continuous variable, we include a fixed effect for *N_PROVID*, where we limit the number of providers seen to 6 (constituting >99% of all observations). We observe that the OLS estimates (listed in Table A4) are increasing in size as the number of providers seen increase (controlling for the number of PCP visits), representing the fact that the care fragmentation is increasing in the number of providers seen.

Table A4 Association between number of providers seen and patient outcomes: Fixed Effects for *N_PROVID*.

	LOG (IP_VISITS)	*LOG (MEAN_LOS)*	*LOG (30D_READ)*
N_PROVID=2	0.0071*	0.0087*	0.0013
	(0.0028)	(0.0035)	(0.0010)
N_PROVID=3	0.0217***	0.0264***	0.0057***
	(0.0046)	(0.0057)	(0.0017)
N_PROVID=4	0.0320***	0.0381***	0.0057*
	(0.0066)	(0.0082)	(0.0027)
N_PROVID=5	0.0524***	0.0647***	0.0173***
	(0.0120)	(0.0149)	(0.0045)
N_PROVID=6	0.0721***	0.0820***	0.0300***
	(0.0169)	(0.0207)	(0.0071)
LOG (PCP_VISITS)	0.0641***	0.0782***	0.0138***
	(0.0078)	(0.0093)	(0.0027)
REST_VISITS	0.0027***	0.0033***	0.0008***
	(0.0002)	(0.0002)	(0.0001)

Notes: Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. *p < 0.05; **p < 0.01; ***p < 0.001.

Using the COC Measure Proposed inBice and Boxerman (1977). A concern could be that that our proposed index (CCI) may have its own quirk and that the conclusions may not hold when other COC measures are used. To address this, we test H1 using a COC measure proposed in Bice and Boxerman (1977) (*BBI*, henceforth), with the key assumption that all the providers are unreferred (the OLS estimates are listed in Table A5). We find that coefficients on BBI are same in direction and significance as those on CCI (Table 4 in the main manuscript). In terms of size, the coefficients on BBI are smaller, approximately 70% of the estimate size on CCI.

Table A5 Association between BBI (Bice and Boxerman 1977) and patient outcomes.

	LOG (IP_ VISITS)	*LOG (MEAN_ LOS)*	*LOG (30D_ READ)*	*LOG (IP_ VISITS)*	*LOG (MEAN_ LOS)*	*LOG (30D_ READ)*
BBI	-0.0231***	-0.0277***	-0.0061***	-0.0584**	-0.0700**	-0.0252**
	(0.0054)	(0.0066)	(0.0017)	(0.0223)	(0.0267)	(0.0087)
BBI^2				0.0296+	0.0355+	0.0160*
				(0.0166)	(0.0200)	(0.0067)
LOG (PCP_ VISITS)	0.0811***	0.0979***	0.0193***	0.0824***	0.0995***	0.0200***
	(0.0073)	(0.0088)	(0.0026)	(0.0071)	(0.0086)	(0.0026)
REST_ VISITS	0.0027***	0.0032***	0.0008***	0.0027***	0.0032***	0.0008***
	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Observations	2,054,404	2,054,404	2,054,404	2,054,404	2,054,404	2,054,404
R-squared	0.158	0.153	0.0631	0.158	0.153	0.0631

Notes: Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. +p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001.

Testing Hypothesis 2: Inclusion of CCI^2 in the model.

Table A6 Association between CCI and patient outcomes as a function of patient severity: Inclusion of CCI^2.

	LOG (IP_ VISITS)	*LOG (MEAN_ LOS)*	*LOG (30D_ READ)*	*LOG (IP_ VISITS)*	*LOG (MEAN_ LOS)*	*LOG (30D_ READ)*
CHARLSON=6 × CCI				-0.0238*	-0.0266*	-0.0087*
				(0.0104)	(0.0128)	(0.0040)
CHARLSON=7 × CCI				-0.0618***	-0.0723***	-0.0254***
				(0.0116)	(0.0145)	(0.0060)
CHARLSON=8 × CCI				-0.0931***	-0.1099***	-0.0343***
				(0.0169)	(0.0210)	(0.0082)
CCI	-0.1267**	-0.1416**	-0.0505**	-0.0868*	-0.0950*	-0.0353*
	(0.0418)	(0.0497)	(0.0157)	(0.0401)	(0.0478)	(0.0152)
CCI^2	0.0685*	0.0750*	0.0306**	0.0603*	0.0653*	0.0275*
	(0.0275)	(0.0328)	(0.0106)	(0.0270)	(0.0322)	(0.0105)
LOG (PCP_ VISITS)	0.0778***	0.0941***	0.0184***	0.0775***	0.0937***	0.0183***
	(0.0074)	(0.0089)	(0.0027)	(0.0074)	(0.0089)	(0.0027)
REST_ VISITS	0.0027***	0.0032***	0.0008***	0.0027***	0.0032***	0.0008***
	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
CHARLSON=6	0.0009	0.0009	-0.0028+	0.0184*	0.0205+	0.0036
	(0.0039)	(0.0048)	(0.0015)	(0.0090)	(0.0109)	(0.0037)
CHARLSON=7	0.0227***	0.0269***	0.0056*	0.0674***	0.0790***	0.0239***
	(0.0066)	(0.0079)	(0.0028)	(0.0112)	(0.0137)	(0.0056)
CHARLSON=8	0.0891***	0.1066***	0.0304***	0.1550***	0.1843***	0.0546***
	(0.0092)	(0.0112)	(0.0035)	(0.0162)	(0.0198)	(0.0076)
Observations	2,054,404	2,054,404	2,054,404	2,054,404	2,054,404	2,054,404
R-squared	0.158	0.153	0.063	0.158	0.153	0.063

Notes: Charlson=5 serves as a reference category. Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. +p < 0.1; *p < 0.05; **p < 0.01; ***p < 0.001.

Appendix A.3. Continuity of Care in practice: Evidence from the VHA

Our results offer a strong suggestion that higher continuity of care can lead to improved outcomes. A key inference that can be drawn is that having a long-term and continuous association with a PCP is likely to improve health outcomes of the patient. Fortunately, we are able to formally validate this hypothesis using PCMM data. Since we know exactly which PCP has been assigned to each patient, along with relationship start and end dates, we can estimate the length of the relationship between a patient-PCP pair. Consequently, for each time period (quarter), we create an indicator variable, $ASSGD\_PCP$ that takes a value of 1 (indicating a long-term relationship) if a patient had a single continuously assigned PCP in the previous four quarters, the same time period used to calculate CCI. We estimate its effect using the following linear model.

$$LOG(Y)_{it} = \beta ASSGD\_PCP + \delta_1 LOG(PCP\_VISITS)_{it} + \delta_2 REST\_VISITS_{it} + \gamma^T CONTROLS\_TV_{it} + \mu^T CONTROLS\_TIV_i + YQ_t + \epsilon_{it}.$$

Here Y represents the main outcome of interest for each time period and β is the coefficient of interest. Our results (listed in Table A7) show that having a continuous long-term association with a PCP improves health outcomes, providing further validation to our conclusions.

Table A7 Effect of long-term relationship with an assigned PCP on health outcomes.

	LOG (IP_ VISITS)	*LOG (MEAN_ LOS)*	*LOG (30D_ READ)*
ASSGD_ PCP	-0.0126***	-0.0157***	-0.0042**
	(0.0033)	(0.0039)	(0.0013)
LOG (PCP_ VISITS)	0.0841***	0.1014***	0.0201***
	(0.0073)	(0.0089)	(0.0026)
REST_ VISITS	0.0027***	0.0032***	0.0008***
	(0.0002)	(0.0002)	(0.0001)

Notes: Robust standard errors clustered at the parent facility level are in parentheses. All specifications include all patient-level controls and time dummies. *p < 0.05; **p < 0.01; ***p < 0.001.