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# After-hours Incentives and Emergency Department Visits: Evidence from Ontario Forthcoming at Canadian Public Policy

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# After-hours Incentives and Emergency Department Visits: Evidence from Ontario
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**Abstract**

One important component of the primary care reform in Ontario, Canada is to incentivize physicians to work "after hours" in order to improve access to core primary care services and potentially reduce visits to hospital emergency departments. Empirically, evidence on this link is ambiguous. We suggest reasons for this ambiguity, and then harness rich administrative data from Ontario to carefully investigate if and why after-hours incentives affect ED usage. The data cover visits to physicians' offices and ED visits from 2003 to 2007, a period with exogenous changes in after-hours incentives. We find strong evidence that nonurgent ED visits are reduced as a result of these incentives.

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# 1 Introduction

Avoidable, or nonurgent, emergency department (ED) visits are commonplace in developed countries (Carret et al., 2009). About 39% of Canadians reported that their ED visits could have been avoided if primary care were available (Schoen et al., 2005). Aside from contributing to overcrowding and delaying care for patients in urgent need, the use of EDs for nonurgent health problems contributes to higher health care costs (Campbell et al., 2005; Mehrotra et al., 2009; Thygeson et al., 2008) and lower continuity of care, adversely affecting health outcomes, especially for patients with chronic conditions (Dunnion and Kelly, 2005; Stiell et al., 2003; Vinker et al., 2004).

Primary care is publicly funded in all jurisdictions in Canada with no direct cost to the patient for physician and hospital visits. While no direct financial cost is borne, ED visits entail long waits before a physician is seen, especially for nonurgent cases. All else being equal, patients would likely prefer to be treated by their family doctor for non-urgent health problems.

Reforms to primary care were introduced in the early 2000s across various jurisdictions in Canada (Health Canada, 2007; Sweetman and Buckley, 2014; Gray et al., 2015). Common across these reforms was a move from traditional fee-for-service (FFS) remuneration towards pay-for-performance incentives for preventive care and chronic disease management (Hutchison et al., 2011;). Several new types of non-FFS primary care delivery models featuring these financial incentives have been introduced in Canada's most populous province, Ontario, since 2004 (Hutchison et al., 2011). By 2010, more than two-thirds of Ontario's family physicians had joined one of these models, with Family Health Organizations (FHO) and Family Health Groups (FHG) being the two most popular choices (Henry et al., 2012).

One of the goals of these new models is to reduce ED visits by increasing access to primary health care services outside of regular working hours. Each physician practicing in these new models is required to provide a minimum of one three-hour session per week either weeknights after 5 pm or on weekends or statutory holidays. In return, these physicians receive an after-hours premium, initially of 10% when first introduced in 2003 and increasing to 15% in April 2005, 20% in April 2006 and then to 30% in September 2011 (Sweetman and Buckley, 2014). The main goal of our paper is to determine whether this policy was successful at reducing ED utilization.

Pay for performance schemes have been studied in several contexts in Ontario (Kantarevic and Kralj, 2013; Li et al., 2014). A handful of studies examine the link between improved after-hours access to primary care and ED visits outside of Canada, with mixed findings. This includes the implementation of an after-hours clinic or cooperative (Buckley et al.,

2010; Pickin et al., 2004), the extension of primary care practice opening hours (Dolton and Pathania, 2016; Harris et al., 2011; Lippi Bruni et al., 2016; Lowe et al., 2005), the reorganization of after-hours care (van Uden and Crebolder, 2004; van Uden et al., 2005), and after-hours financial incentives (Franco et al., 1997; Piehl et al., 2000). This literature guides our choice of variables in the analyses.

At least two reasons explain why increased after-hours services may not reduce ED visits unambiguously: Firstly, ED visits would fall only if patients have conditions that are otherwise treatable by primary care physicians; no amount of after-hours care would reduce visits to the ED for the most urgent-need patients. Secondly, while ED visits may fall because of increased after-hours services, they may rise if regular-hours services are reduced.

We use a rich, longitudinal data set that allows us to control otherwise unobserved heterogeneity and to exploit exogenous variation in the strength of after-hours incentives, which helps establish the impact of these incentives on ED visits. The large number of physicians in this data set also allows us to estimate this impact by different subgroups of physicians, such as those with sicker patients. As expected, regular- and after-hours services move in opposite directions in response to stronger after-hours incentives. We find that after-hours services reduce nonurgent ED visits. Most nonurgent ED reductions come from practices with below-median co-morbidity, suggesting that after-hour incentive reduces ED visits from healthier patients, allowing more time for more urgent visits.

# 2 Data and Variables

Several administrative databases held at the Institute for Clinical Evaluative Sciences (ICES) provide the data for this study. The Physician Database contains characteristics of primary care physicians; the Corporate Provider Database provides physicians' model type, effective date of eligibility for billing under the Ontario Health Insurance Plan ("OHIP", the public insurer/payer) and physician group size. The Client Agency Program Enrollment Database allows us to match physicians with enrolled patients. If a physician was affiliated with more than one practice type, the most recent one joined was selected. Only physicians who put in a claim for after-hour incentives to the public insurer (OHIP) are in our sample.[1] The billing codes eligible for the after-hours premium correspond to fairly basic services that most physicians provide—like minor assessments, primary mental health care, counseling, and annual physical examinations. Knowing this, we expected an appreciable effect of premium

[1]The OHIP billing codes used to compute after-hour costs are A001, A003, A004, A007, A008, A888, K005, K013, K017, K033, K030, Q050, K130, K131, and K132; the after-hours premium codes are Q12 and Q16.

changes on ED utilization. We exclude part-time physicians, defined as having fewer than 500 patients or 500 visits in any given year. We focus on data spanning 2003-2007, with 1,321 unique physicians and 6,605 physician-year observations comprising the balanced panel we use for our analysis.[2]

Patient visits to a physician were identified through OHIP billing claims. For each physician, total annual office visits were derived as the sum of patient visits.[3] The total number of annual office visits minus the total number of annual after-hour visits defines regular visits for each physician. Group size sums up the number of primary care physicians with the same group number.

Emergency department visits come from the National Ambulatory Care Reporting System which classifies them into urgent and nonurgent based on the Canadian Triage and Acuity Scale (CTAS) (Beveridge et al., 1999). A triage level of 1 (resuscitation), 2 (emergent), or 3 (urgent) is urgent, while 4 (less-urgent/semi-urgent) or 5 (nonurgent) was not; we aggregate these into three mutually exclusive categories, where group 1 ("very urgent") contains ED visits with a CTAS score of 1 or 2, group 2 ("urgent") contains ED visits with a CTAS score of 3, and group 3 ("nonurgent") contains ED visits with a CTAS score of 4 or 5.[4] The Aggregated Diagnosis Group (ADG) reflecting the health status of each patient is based on their diagnosis codes from the hospital Discharge Abstract Database (DAD) and OHIP, using the Johns Hopkins Adjusted Clinical Group case-mix adjustment system. There are 32 diagnosis groups, which we sum so that each patient has a score between 1 and 32. For each physician, we calculate the average ADG of her patients.

Ontario's health registry database (the Registered Persons Database) provides patients' age, sex and postal codes which we use to obtain deprivation and rurality indices around the patient's residence ("census dissemination area"). The deprivation index is organized into quintiles, where 1 is least marginalized and 5 is most marginalized—our measure is the percent of physician's patients from the fourth and fifth quintiles (i.e., the most deprived areas)—and individuals with a rurality index of 40 or higher are considered to reside in rural areas (Kralj, 2000; Matheson et al., 2012).[5]

[2]We have data covering 2003-2013. However, beginning in 2008, a large number of FPs switched to the Family Health Organization model, a capitation-based payment system found to change physician practice patterns (Zhang and Sweetman, 2018). As these changes may confound our analysis of the impact of after-hours incentives on ED visits, we restricted our analysis to the years 2003-2007. Furthermore, using a balanced panel eliminates potential attrition bias stemming from the retirement of physicians.

[3]Patient visits are defined as the combination of billing codes and the serve date in OHIP (i.e. the date the service(s) were provided to patients). Multiple billing codes in the same date are defined as a one visit, but two billing codes in two separate dates are defined as two visits.

[4]Unfortunately, the sample sizes in CTAS 1 and 5 were not large enough to permit us to use all five categories in our analyses.

[5]The (material) deprivation index is a composite score based on the proportion of the population in the

Table 1 reports descriptive statistics of regular-hours, after-hours, and ED utilization by year. Between 2003 and 2007, the number of regular-hours visits per 1,000 patients decreased; after-hours visits per 1,000 patients increased and then fell near the end. Correspondingly, total costs per 1,000 patients decreased substantially, even though after-hours costs almost doubled (all in 2002 Canadian dollars).[6] During the same period, the number of very urgent ED visits increased, urgent ED visits increased sharply initially and then stayed roughly constant, and the number of nonurgent ED visits also increased sharply and then gradually decreased. Table 2 presents statistics pooled over the sample period and shows that after-hours visits comprise about 11% of physicians' total visits on average.

# 3 Empirical Framework

The net effect of increasing the after-hours premium on ED visits is ambiguous. We start by estimating the regression[7]

$$\mu_{it} = \rho_{\mu,\pi}\pi_t + Z'_{it}\beta_{\mu,\pi} + \epsilon_{it,\mu,\pi}, \tag{1}$$

where $\mu_{it}$ can be total, nonurgent, urgent, or very urgent ED visits per 1,000 patients for physician $i$ in year $t$; $\pi_t$ is the after-hours premium in year $t$; $Z_{it}$ includes a time trend, physician's age, physician's age squared, proportion of female physicians and foreign graduates in the physician's practice, group size, average age of patients, average ADG score of patients, proportion of patients living in deprived areas, and proportion of patients living in rural areas; and $\epsilon_{it,\mu,\pi}$ represents the error term. We estimate the regression using both OLS and physician fixed effects, which means the error term may include a fixed-effect component for the physician. However, the net effect of increasing the after-hours premium on overall costs may be ambiguous, even if nonurgent ED visits decrease due to the after-hours premium increase. We thus re-estimate the model using total costs as the dependent variable.

To examine how physician behaviour is affected by incentivizing after-hours access, we estimate a model of services provided by physician $i$ during year $t$ (using OLS and physician

census area aged 25+ years old without a certificate, diploma, or degree; the proportion of single-parent families; the proportion receiving government transfer payments, the proportion those aged 15+ who are unemployed, the proportion considered low-income, and the proportion living in homes of in need of major repair; ethnic concentration is a composite score based on neighbourhood level proportions, including the proportion who are recent immigrants (within 5 years) and the proportion of those who identify as self-minorities (Matheson et al., 2018).

[6]Note that by "after-hours costs" we refer to the value of after-hours services, excluding the after-hours premium.

[7]We adopt the notational convention of subscripting regression coefficients with the dependent variable first and then the primary regressor of interest.

FE):

$$x_{it} = \rho_{x,\pi}\pi_t + Z'_{it}\beta_{x,\pi} + \epsilon_{it,x,\pi}, \tag{2}$$

where $x_{it}$ can be either regular- or after-hours services (analyzed separately), measured by either visits per 1,000 patients or (deflated) costs per 1,000 patients (i.e., the value of services in 2004 prices); $\pi_t$ is the premium level in year $t$; $Z_{it}$ contains the variables from equation (1); and $\epsilon_{it,x,\pi}$ represents the error term, which may include a fixed-effect component for the physician. As fee-for-service physicians do not receive after-hours premiums, we focus our analysis on physicians who have switched into a scheme that incentivizes after-hours services (recall that we restrict our analysis to go until 2007, before the large transition to FHO occurred).

Next, we estimate how ED visits vary with respect to the value of after-hours services in 2004 prices, using the regression model (estimated using OLS and physician FE)

$$\mu_{it} = \rho_{\mu,x}x_{it} + Z'_{it}\beta_{\mu,x} + \epsilon_{it,\mu,x}, \tag{3}$$

where $\mu_{it}$ can be total, nonurgent, urgent, or very urgent ED visits per 1,000 patients for physician $i$ in year $t$; $x_{it}$ represents the value of after-hours services in 2004 prices; $Z_{it}$ contains the variables from equation (1); and $\epsilon_{it,\mu,x}$ represents the error term, which may include a fixed-effect component for the physician.

One might wonder whether physicians would engage in "gaming" in response to the financial incentives. They could, for instance, encourage their patients to come during after-hours in order to gain the premium. If all changes in after-hours services were driven by gaming behaviour there would be no change in the provision of primary care and, thus, no effect on ED visits. Our empirical approach takes into account this potential for gaming, as we estimate the net effect of premium increases on ED utilization. Evidence of an effect of after-hours premium increases on ED visits would suggest such gaming is not the dominant force at play. From a practical perspective, however, the regulatory framework affords very limited scope for gaming. Physicians are required to post their after-hours availability to patients, and the incentives are applicable only to enrolled patients seen during posted after-hours sessions. Physicians are free to provide services to non-enrolled patients but these are not eligible for after-hours incentives.

# 4 Empirical Findings

**Effect of after-hours incentives on ED utilization:** Table 3 provides the estimated coefficients from the OLS and fixed effects models of ED visits (total, and split by urgency

group) on the after-hours premium as well as physician and practice characteristics (equation (1)). From the OLS results in the left panel, the estimated coefficients on the after-hours premium (*premium*) are negative across the board. Not only do total ED visits fall, but so too do the visits of all groups (with nonurgent visits being statistically insignificant). The last result is surprising insofar as one would expect that nonurgent visits would decrease after the introduction/strengthening of after-hours incentives for regular physicians. The OLS procedure does not control for time-invariant physician heterogeneity which affects the reliability of these estimates. Indeed, when we take account of physician level fixed effects, these results change quite significantly. From the right-hand side of Table 3, we find that the after-hours premium exerts a a negative and statistically significant impact for the nonurgent group (specification (6)) and a positive and statistically significant impact on more urgent ED visits (specifications (8) and (7)). Together, these findings support the idea that the after-hours premium encouraged those patients with nonurgent conditions to seek care at their physician's office, thus reducing their crowding out of more urgent ED visits. We also see that female physicians tend to have fewer ED visits, as do international medical graduates (*IMG*) and those physicians who practice in larger practices (*group size*). Physicians with younger patients (*avg. age*), fewer deprived patients (*avg. deprived*), and fewer rural patients (*avg. rural*) also have fewer ED visits. Physicians with higher mean patient ADGs (*avg. ADG*) have more very urgent ED visits and fewer nonurgent ED visits.

**Effect of after-hours incentives on services:** If increasing the after-hours premium reduces ED utilization by changing physician behaviour, this should show up in the data. Office visits are one measure of physician behaviour but may not be ideal because the amount of services provided per visit may change if the after-hours premium changed. The rich data used in this study enable us to use two measures of physician after-hours services: visits and the value of services provided. Value of services provided are a good measure of services rendered if service prices capture input amounts. We construct price-adjusted values, "after-hours values" and "regular values", by correcting for the change in the prices of services (in 2004 values), excluding the after-hours bonuses (which were, e.g., 10% in 2004). We use these deflated values as our primary measure of services in our empirical analysis.

Table 4 presents the fixed-effects results from regressing measures of services on the after-hours premium (equation (2)). Specification (1) regresses after-hours visits on the premium, and finds a positive and significant estimated coefficient: a higher premium is correlated with more after-hours visits. Specification (2) uses the (deflated) value of after-hours services—i.e., the cost, adjusted for changes in the premium and in the prices of services—as the measure of services rendered, and finds a strong positive relationship between

the premium amount and services. Specification (3) examines how the after-hours premium affects regular visits, and reveals the expected negative, significant, effect. Specification (4) examines how the (deflated) value of *all* services co-vary with the premium, and finds a negative, significant effect. As total costs include regular and after-hours costs, this implies that the regular costs measure of services provided during regular hours must have decreased. In short, both measures of services provided after hours increase in response to increases in the premium, while both measures of services provided during regular hours decrease in response to premium increases.

**Effect of after-hours services on ED utilization:** The fixed-effects estimates of the impact of the after-hours premium on ED visits indicate that they fell for the nonurgent group (Table 3), while after-hours physician services, not surprisingly, increased (Table 4). Table 5 summarizes the relationship between after-hours costs and ED utilization, using OLS (first row) and fixed-effects (second row) estimates of equation (3). The OLS results are presented for comparison purposes, but we focus on the fixed-effects ones. The fixed-effects estimates show that, while increases in after-hours services do not decrease overall ED visits (specification (1)), they do significantly decrease the least-urgent ED visits (specification (2)); they are also associated with small (but statistically significant) increases in urgent ED visits (specification (3)) but are not associated with any change in very urgent ED visits (specification (4)).

The fixed-effects models control for time-invariant physician heterogeneity and provide evidence that increases in after-hours services reduce nonurgent ED visits. We can provide even stronger evidence supporting the link between after-hours services and ED visits by exploiting variation in the after-hours premium over time as an instrument, and using a fixed-effects instrumental variables estimation approach. Because changes in the after-hours premium over time are exogenous[8], the premium is arguably a valid instrument in the ED utilization equations. Given the higher wage rate faced by physicians during after-hours sessions as well as regulations governing the minimum number of these sessions, we expect the after-hours premium to be highly correlated with after-hours services. This is confirmed by the large F-statistics in the first-stage regression (see Table 6). Moreover, there is no a priori reason to expect the after-hours premium awarded family physicians to affect ED utilization other than indirectly through the increased provision of incentivized services during after-hours.

Specification (1) of Table 6 shows there is no significant estimated impact of after-hours

[8]Even if the policy to increase after-hours premiums were made in response to an undesirably large number of ED visits, it is exogenous to the actions of any given physician.

services on *total* ED visits. However, specification (2) shows that there *is* a significant reduction stemming from increases of after-hours services on the least-urgent ED visits. Estimates of the effect on urgent and very urgent ED visits are positive and statistically significant, yet smaller in magnitude than the effect on nonurgent ED visits. These results corroborate those of the fixed-effects models, namely: increasing the after-hours premium increases physicians' provision of after-hours services, which leads to a reduction in nonurgent ED visits. The advantage of the instrumental variables estimates is that they isolate physician behaviour as the channel affecting ED utilization.

Up to now, we see that increasing the after-hours premium reduces ED visits for nonurgent patients by way of increasing physicians' after-hours services. Now we want to determine if this affects overall health-system costs. Using values for ED visits (2002 dollars) from the Ministry of Health[9], we estimate

$$\$\mu_{it} = \rho_{\$\mu,x}\$x_{it} + Z'_{it}\beta_{\$\mu,x} + \epsilon_{it,\$\mu,x}, \tag{4}$$

where $\$\mu_{it}$ is the cost of ED visits per 1,000 patients and $\$x_{it}$ is the cost of after-hours incentive per 1,000 patients. Note the cost of the after-hours incentive used in this specification includes the increase in premium. Here, we are primarily interested in the estimate of $\rho_{\$\mu,x}$, the change in ED costs with respect to after-hours costs.

Table 7 presents fixed-effects instrumental variables estimates of after-hours services on ED costs. The increase in after-hours services (due to the higher after-hours premium) results in reductions in the least urgent ED costs (specification (2)). By dividing the estimated ED cost savings by the estimated reduction in nonurgent ED visits, $\frac{-\$0.6442 \text{ per 1,000 patients per physician per year}}{-0.00432 \text{ visits per 1,000 patients per physician per year}}$, we see a cost savings of about \$149 per reduced ED visit. This calculation exploits changes in costs and visits induced by variations in the after-hours premium, and as such represents the mean costs of treating inframarginal patients at the nonurgent ED. The increase in costs due to more urgent care visits is of a much smaller magnitude than the cost savings found for nonurgent ED visits. Overall, our results suggest that the after-hours policy contributed to a reduction in ED costs.

Finally, it is likely that reductions in ED visits are not uniformly distributed over all practices. In particular, in practices with healthier patients, increased after-hours services may allow patients with less-urgent conditions to be treated by their physicians rather than the ED, as opposed to practices with high-morbidity patients who may need to go to the ED irrespective of the availability of after-hours sessions. To examine this possibility, we re-run

[9]Specifically, ED costs were derived by multiplying the resource intensity weight available from NACR database with the average cost case by the cost per weighted case. This is the standard procedure commonly used to calculate costs at the population level (Wodchis et al., 2013).

our prior fixed-effects regressions for two subsamples of practices: those with below-median average patient ADG and those with above-median average patient ADG.

The first row of Table 8 reports the change in ED visits with respect to after-hours services (measured by after-hours costs), split by whether practices have low and high mean ADGs. The results from specifications (3) and (4) indicate a significant negative relationship with respect to value of after-hours services and nonurgent ED visits; the estimated relationship for urgent ED visits is positive, but much smaller in magnitude. In the second row, we find that the response of nonurgent ED costs with respect to after-hours services is -0.109 for practices with below-median mean ADG, while it is not significantly different from zero at practices with above-median mean ADG. The finding that changes in ED costs are driven by physicians with relatively healthy (and, therefore, easier to treat) patients is consistent with the idea that premium changes affect ED utilization via physician behaviour.

# 5 Concluding Remarks

Our results show that the after-hours incentive in Ontario's primary care setting resulted in more nonurgent patients seeing their family physicians, reducing nonurgent ED visits. Our paper has several strengths. We provide empirical evidence using novel health administrative data from Ontario that after-hours incentives reduce ED visits. Moreover, we are able to investigate the impact of after-hours incentives on ED utilization at the intensive margin. We uncover evidence that after-hours incentives reduce nonurgent ED utilization, stemming largely from practices with healthier patients, rather than those with sicker ones.

We noted earlier that, although we have data from 2003-2013, we focus our analysis on 2003-2007. In addition to an increase in the after-hours premium from 20% to 30%, there were several additional changes in the institutional environment from 2008-2013, including the introduction of additional pay for performance incentives and that many physicians switched to FHO and team settings, which was found to reduce services in FHO baskets (Zhang and Sweetman, 2018). We conducted a robustness analysis covering this later period, and found several qualitatively similar results, which we present in an Online Appendix. Briefly, similar to the 2003-2007 period, Online Appendix Table 9 shows that increases in the premium are associated with statistically significant reductions in nonurgent ED visits (specifications (2) and (6)). Online Appendix Table 10 shows that there are significant reductions in regular visits and costs (specifications (3) and (4)), although specifications (1) and (2) do not show significant increases in after-hours services, as measured by either visits or costs. The within-physician (fixed-effects) estimates presented in the second row of Online Appendix Table 11 show that increases in after-hours services reduce nonurgent ED visits

(specification (2)), similar to the results from 2003-2007. Finally, similar to our results from 2003-2007, Online Appendix Table 12 shows significant reductions in ED costs associated with nonurgent visits (specification (2)).

One interesting direction for future work concerns the after-hours premium itself. For example, a constant after-hours premium may not be the most cost-effective, and one that differs with disease severity may lead to further health-system savings. Examining the optimal non-linear incentive structure would be fruitful. Another point for future research is whether after-hours incentives work differently in retrospective and perspective payment systems. Finally, it would be useful and pertinent to examine the extent to which these reforms resulted in more individuals finding a regular family doctor—potentially reducing their reliance on ED visits.

Like other studies using administrative data, we are limited as to the variables available for empirical analyses. The lack of socio-economic information on physicians and their patients, including information on family income, constrains the work. Such data would enhance future research in this area.

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Table 1: Sample means, by year (2003-2007)

| Year | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Premium | 0.10 | 0.10 | 0.15 | 0.20 | 0.20 |
| Obs. | 1321 | 1321 | 1321 | 1321 | 1321 |
| Below variables are per 1,000 patients | | | | | |
| Regular-hours visits | 4129.85 | 3096.45 | 2968.89 | 2933.39 | 2751.81 |
| After-hours visits | 224.94 | 402.10 | 408.39 | 379.91 | 350.26 |
| Total costs (deflated) | 173 668.80 | 142 387.30 | 140 541 | 134 611.60 | 125 896.30 |
| After-hours costs (deflated) | 6295.60 | 11 251.11 | 11 860.40 | 11 073.03 | 10 228.15 |
| Very urgent ED visits | 35.67 | 43.40 | 47.79 | 50.37 | 54.65 |
| Urgent ED visits | 138.58 | 147.07 | 151.62 | 152.62 | 152.89 |
| Nonurgent ED visits | 138.58 | 183.78 | 177.37 | 176.03 | 173.65 |

Note: "very urgent", "urgent", and "nonurgent" ED visits respectively correspond to CTAS groups 1, 2, and 3.

Table 2: Sample means and standard deviations, pooled over all years

| Variable | Mean | Std. Dev. |
|---|---|---|
| Age | 48.96 | 8.61 |
| Female | 0.32 | 0.46 |
| IMG | 0.08 | 0.26 |
| Group size | 23.18 | 28.33 |
| Roster size | 1773.75 | 666.15 |
| Avg. age | 38.47 | 5.29 |
| Avg. ADG | 3.18 | 0.38 |
| Avg. deprived | 23.12 | 13.02 |
| Avg. rural | 12.50 | 22.20 |
| Premium | 0.12 | 0.05 |
| Below variables are per 1,000 patients | | |
| | Mean | Std. Dev. |
| Regular-hours visits | 3176.08 | 1006.39 |
| After-hours visits | 353.12 | 319.02 |
| Very urgent ED visits | 46.38 | 21.83 |
| Urgent ED visits | 148.56 | 49.30 |
| Nonurgent ED visits | 169.88 | 119.86 |
| After-hours costs (deflated) | 10 141.66 | 9317.56 |
| Total costs (deflated) | 143 421 | 47 742.82 |
| Very urgent ED costs | 16 876.07 | 8254.99 |
| Urgent ED costs | 35 443.63 | 11 456.86 |
| Nonurgent ED costs | 25 882.34 | 18 176.57 |
| Total ED costs | 78 210.01 | 27 569.96 |
| Obs. | 6605 | |

Note: "very urgent", "urgent", and "nonurgent" ED categories respectively correspond to CTAS groups 1, 2, and 3.

Table 3: Change in emergency department visits, as function of after-hours premium and other covariates

| | OLS | | | | | | | | FE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total visits | | Nonurgent | | Urgent | | Very urgent | | Total visits | | Nonurgent | | Urgent | | Very urgent | |
| | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | | (8) | |
| | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. |
| Premium | −126.261 | 33.860 | −1.353 | 27.732 | −33.918 | 16.837 | −16.591 | 8.732 | 32.307 | 17.137 | −56.890 | 21.046 | 43.297 | 6.648 | 11.839 | 4.239 |
| Year | 4.120 | 1.437 | 1.786 | 1.166 | 2.990 | 0.698 | 4.472 | 0.370 | −10.556 | 3.310 | 0.084 | 3.838 | −0.087 | 1.277 | 3.391 | 0.771 |
| Age | −7.493 | 2.932 | −1.919 | 2.011 | −2.899 | 1.108 | −0.518 | 0.455 | | | | | | | | |
| Age sq. | 0.055 | 0.029 | 0.008 | 0.020 | 0.022 | 0.011 | 0.005 | 0.005 | 0.135 | 0.028 | −0.008 | 0.036 | 0.017 | 0.012 | 0.004 | 0.007 |
| Female | −13.213 | 6.584 | 4.550 | 4.263 | −6.057 | 2.449 | −7.684 | 0.960 | | | | | | | | |
| IMG | −38.437 | 9.915 | −21.445 | 6.597 | −13.093 | 3.698 | −7.419 | 1.677 | | | | | | | | |
| Group size | −0.331 | 0.060 | −0.177 | 0.039 | −0.184 | 0.025 | −0.025 | 0.011 | 0.048 | 0.026 | −0.079 | 0.028 | −0.013 | 0.011 | 0.010 | 0.006 |
| Avg. age | 5.207 | 0.705 | 2.195 | 0.469 | 2.312 | 0.245 | 1.058 | 0.109 | 1.208 | 1.653 | 0.987 | 1.501 | 0.464 | 0.450 | 0.547 | 0.210 |
| Avg. ADG | −12.750 | 8.329 | −20.765 | 5.652 | 0.950 | 3.073 | 6.276 | 1.317 | 8.862 | 8.302 | 8.728 | 7.747 | 7.897 | 2.486 | 1.964 | 1.461 |
| Avg. deprived | 3.648 | 0.260 | 2.662 | 0.267 | 1.300 | 0.096 | 0.447 | 0.046 | 0.382 | 0.159 | 5.103 | 0.566 | 0.171 | 0.059 | 0.096 | 0.027 |
| Avg. rural | 3.979 | 0.303 | 3.061 | 0.249 | 0.303 | 0.064 | −0.148 | 0.018 | 3.580 | 1.083 | −0.177 | 0.504 | 0.298 | 0.154 | −0.046 | 0.107 |
| Constant | -7918.8 | 2879.5 | -3449.7 | 2339.4 | -5874.5 | 1397.5 | -8969.0 | 739.6 | 21072.0 | 6545.4 | -150.7 | 7588.3 | 225.3 | 2530.7 | -6791.7 | 1528.8 |
| Obs. | 6605 | | 6605 | | 6605 | | 6605 | | 6605 | | 6605 | | 6605 | | 6605 | |

Note: All regressions include the full set of control variables, $Z_{it}$. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 1321 clusters.

Table 4: Fixed-effects regressions of regular- and after-hours services on after-hours premium and other characteristics

| | After-hours visits | | After-hours costs | | Regular visits | | Total costs | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Premium | 436.649 | 69.423 | 13 166.930 | 2048.579 | −2223.516 | 244.539 | −58 298.540 | 10 185.040 |

Note: All regressions include the full set of control variables, $Z_{it}$. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 6605 observations and 1321 clusters. Full results are in Online Appendix Table 13.

Table 5: Change in emergency department visits, with respect to after-hours services

| | Total visits | | Nonurgent | | Urgent | | Very urgent | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| OLS | −0.002 80 | 0.000 27 | −0.001 72 | 0.000 20 | −0.000 82 | 0.000 10 | −0.000 06 | 0.000 06 |
| FE | 0.000 19 | 0.000 15 | −0.001 27 | 0.000 25 | 0.000 18 | 0.000 06 | 0.000 06 | 0.000 04 |

Note: All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 6605 observations and 1321 clusters.

Table 6: IV Estimate of effect of after-hours services on ED visits

| | Total visits | | Nonurgent | | Urgent | | Very urgent | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| After-hours costs | 0.002 46 | 0.001 34 | −0.004 32 | 0.001 65 | 0.003 29 | 0.000 69 | 0.000 90 | 0.000 36 |
| F-stat | 41.20 | | | | | | | |

Note: The Stata command `xtivreg2` was used to estimate these regressions. All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Standard errors are clustered at physician level; there are 6605 observations and 1321 clusters.

Table 7: IV estimate of effect of after-hours services on ED costs

| | Total cost | | Nonurgent cost | | Urgent cost | | Very urgent cost | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| After-hours costs | −0.1979 | 0.2452 | −0.6442 | 0.1908 | 0.2258 | 0.1202 | 0.2196 | 0.1320 |
| F-stat | 41.20 | | | | | | | |

Note: "very urgent", "urgent", and "nonurgent" ED categories respectively correspond to CTAS groups 1, 2, and 3. The Stata command xtivreg2 was used to estimate these regressions. All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Standard errors are clustered at physician level; there are 6605 observations and 1321 clusters.

Table 8: Changes in ED visits and costs, with respect to after-hours services

| | Total | | | | Nonurgent | | | | Urgent | | | | Very urgent | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. ADG low | | Avg. ADG high | | Avg. ADG low | | Avg. ADG high | | Avg. ADG low | | Avg. ADG high | | Avg. ADG low | | Avg. ADG high | |
| | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | | (8) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| ED visits | −0.000 06 | 0.000 35 | 0.000 19 | 0.000 15 | −0.001 12 | 0.000 52 | −0.001 14 | 0.000 31 | 0.000 49 | 0.000 14 | 0.000 06 | 0.000 07 | 0.000 09 | 0.000 06 | −0.000 006 | 0.000 047 |
| ED costs | −0.002 99 | 0.062 17 | 0.022 77 | 0.034 62 | −0.108 50 | 0.040 67 | 0.018 07 | 0.015 53 | 0.086 99 | 0.033 54 | 0.007 68 | 0.021 29 | 0.018 33 | 0.022 39 | −0.002 996 | 0.016 627 |

Note: "Very urgent", "urgent", and "nonurgent" ED categories respectively correspond to CTAS groups 1, 2, and 3. "Avg. ADG low" and "high" respectively refer to practices where mean patient ADG is below and above the sample median mean practice ADG. All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 6605 observations and 1321 clusters.

Table 9: ONLINE APPENDIX: Change in emergency department visits, as function of after-hours premium and other covariates (2007-2013)

| | OLS | | | | | | | | FE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total visits | | Nonurgent | | Urgent | | Very urgent | | Total visits | | Nonurgent | | Urgent | | Very urgent | |
| | (1) | | (2) | | (3) | | (4) | | (5) | | (6) | | (7) | | (8) | |
| | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. | Coef. | St. Err. |
| Premium | −66.367 | 15.930 | −47.570 | 11.186 | −12.505 | 6.246 | −3.985 | 3.047 | −19.386 | 7.266 | −22.103 | 5.776 | 3.463 | 3.537 | 1.599 | 2.132 |
| Obs. | 26,229 | | 26,229 | | 26,229 | | 26,229 | | 26,229 | | 26,229 | | 26,229 | | 26,229 | |

Note: "Very urgent", "urgent", and "nonurgent" ED categories respectively correspond to CTAS groups 1, 2, and 3. All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 26229 observations and 3747 clusters.

Table 10: ONLINE APPENDIX: Fixed-effects regressions of regular- and after-hours services on after-hours premium and other characteristics (2007-2013)

| | After-hours visits | | After-hours costs | | Regular visits | | Total costs | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Premium | 25.114 | 38.243 | −1969.060 | 1134.828 | −1108.476 | 185.159 | −60 146 | 6361.081 |

Note: All regressions include the full set of control variables, $Z_{it}$. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 26229 observations and 3747 clusters.

Table 11: ONLINE APPENDIX: Change in emergency department visits, with respect to after-hours services (2007-2013)

| | Total visits | | Nonurgent | | Urgent | | Very urgent | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| OLS | −0.002 20 | 0.000 18 | −0.001 06 | 0.000 09 | −0.000 86 | 0.000 07 | −0.000 28 | 0.000 03 |
| FE | −0.000 28 | 0.000 08 | −0.000 21 | 0.000 06 | −0.000 08 | 0.000 04 | 0.000 01 | 0.000 02 |

Note: "Very urgent", "urgent", and "nonurgent" ED categories respectively correspond to CTAS groups 1, 2, and 3. All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 26229 observations and 3747 clusters.

Table 12: ONLINE APPENDIX: Changes in ED costs, with respect to after-hours services (2007-2013)

| | Total cost | | Nonurgent cost | | Urgent cost | | Very urgent cost | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| OLS | −0.4254 | 0.0361 | −0.1507 | 0.0137 | −0.1845 | 0.0167 | −0.0894 | 0.0100 |
| FE | −0.0376 | 0.0155 | −0.0356 | 0.0088 | −0.0123 | 0.0089 | 0.0106 | 0.0068 |

Note: "Very urgent", "urgent", and "nonurgent" ED categories respectively correspond to CTAS groups 1, 2, and 3. All regressions include the full set of control variables, $Z_{it}$. After-hours services are measured using deflated after-hours costs. Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 26229 observations and 3747 clusters.

Table 13: ONLINE APPENDIX: Fixed-effects regressions of regular- and after-hours services on after-hours premium and other characteristics

| | After-hours visits | | After-hours costs | | Regular visits | | Total costs | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Premium | 436.649 | 69.423 | 13 166.930 | 2048.579 | −2223.516 | 244.539 | −58 298.540 | 10 185.040 |
| Year | 8.000 | 12.475 | 374.644 | 363.682 | −392.729 | 56.335 | −15 179.900 | 2220.844 |
| Age sq. | −0.132 | 0.120 | −4.175 | 3.515 | 2.422 | 0.538 | 85.532 | 20.591 |
| Group size | 0.432 | 0.126 | 13.230 | 3.866 | 0.037 | 0.458 | 18.283 | 21.566 |
| Avg. age | −9.187 | 3.898 | −262.267 | 116.235 | 41.953 | 29.158 | 1736.373 | 1079.795 |
| Avg. ADG | −15.247 | 23.388 | −473.423 | 731.220 | 268.685 | 139.306 | 7911.881 | 5508.647 |
| Avg. deprived | 5.114 | 0.685 | 133.383 | 19.264 | −21.123 | 2.768 | −588.098 | 91.350 |
| Avg. rural | −3.938 | 1.517 | −111.980 | 44.178 | 12.102 | 6.401 | 553.658 | 306.966 |
| Constant | −15 088.580 | 24 719.630 | −722 637.500 | 720 612.300 | 782 735.400 | 111 712.100 | 3.030e7 | 4 402 387 |
| Obs. | 6605 | | 6605 | | 6605 | | 6605 | |

Note: Fixed-effects are at physician level. Standard errors are clustered at physician level; there are 6605 obesrvations and 1321 clusters.