End-of-Life Medical Spending: Evidence from Pet Insurance

Mary Kate Batistich
Purdue University

Kevin J. Mumford
Purdue University

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Abstract

This paper contributes to the literature on the causal effect of end-of-life medical spending by focusing on the pet health care industry. Using administrative records and an identification strategy based on the timing of pet health insurance benefit renewal, we create an environment in which arrival of insurance benefits is quasi-random. We focus on how the availability of health insurance reimbursement funds affects spending, veterinary visits, and mortality over a two-year period after a serious cancer diagnosis. Increases in the generosity of health insurance reimbursement causes increases in both spending and veterinary visits, but we do not find evidence of a causal effect on mortality.

JEL Codes: I21, J24

Keywords: Health Insurance; End of Life Medical Spending; Pets

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I Introduction

In the United States, a large fraction of health spending happens in the last year of life.[1] The important question for policy makers is to what extent does increased medical care spending cause an increase in health for patients diagnosed with a high-mortality-rate illness. In both the RAND Health Insurance Experiment (Newhouse, 1993) and the Oregon Experiment (Finkelstein et al. 2012), there was no clear improvement in health as a result of the increase in health spending. Long lifespans make death rates a noisy outcome when working with small samples or short time periods. One problem is that both studies focused on health in general, rather than on increased health spending for those at an elevated risk of dying.

Unfortunately, the literature does not have a clear answer to the question, even when focused on those with an elevated risk of dying. Identifying a causal effect of additional health care spending is difficult because health insurance benefits are generally not random. In the United States, people with better jobs tend to have better health insurance. Using quasi-experimental methods has not produced consistent results. For example, using geographic variation in health care spending for serious illnesses, Skinner, Fisher, and Wennberg (2005) find no decrease in the mortality rate. However, using differences in hospital quality for patients with a life-threatening illness who were randomly allocated between hospitals, Joseph J. Doyle (2011) finds that increased spending was associated with lower mortality. Melberg (2018) provides a helpful review of this literature.

In this paper we contribute to this literature by focusing on the pet health care industry. Using a creative identification strategy based on the timing of benefit renewal, we create an environment in which arrival of benefits is quasi-random. And because pet lifespan is much shorter, we are able to explore death rates as a reliable measure of health outcomes.

While pets are not people, we believe there is much to be learned from the pet health care industry. Researchers have noted striking similarities between human and pet health care

[1] Aldridge and Kelley (2015) estimate that 13 percent of health care costs in the United States was for care in the last year of life.

spending patterns. Using a small extract of billing data from a pet hospital in California, Einav, Finkelstein, and Gupta (2017) document a large end-of-life spike in spending for dogs diagnosed with lymphoma. They compare this spending spike to a similar increase for Medicare patients diagnosed with lymphoma. They also note that "most dogs die cheaply" because there is no sharp increase at the end of life for the median dog, as opposed to the median Medicare patient. Instead, a smaller group of dogs drive the sharp end-of-life spending increase. As noted by these authors, the pet owners' financial status is likely an important component of pet health care decisions and ultimate outcomes.

In this paper we focus specifically on how the availability of health insurance reimbursement funds affects pet health after a serious cancer diagnosis. We analyze a sample of dogs who have been diagnosed with very serious cancer, and who have a health insurance plan. We ask whether the availability of insurance benefits affects the amount of treatment the dog undergoes. Availability of benefits varies exogenously by the point in time during the policy term that the dog is diagnosed. A policyholder whose dog is diagnosed late in the policy term will have the option to "double up" on benefits, by using the benefits available to them this term now, and the benefits available to them next term in the near future. Policyholders whose dogs are diagnosed early in the term, in contrast, will have to wait nearly a year for their benefits to renew. We ask whether this difference in timing has any effect on the policyholder's pet care decisions.

Our analysis is guided by a two-period model in which pet owners make cancer treatment decisions by responding to current and future benefit availability, the cost of treatment, and the probability that the treatment will be successful. Given that the treatment is expensive enough to prohibit at least some pet owners from treating, the decision to treat is increasing in the probability that the treatment will be successful. We demonstrate that the probability of successful treatment is conditional on the age of pet, where older dogs are less likely to survive the initial months of treatment. Because of this, pet owners tend to spend less on older dogs with the same diagnosis. In the next stage of analysis, we hold the success probability fixed by analyzing each age group separately, and including additional age controls.

We then turn to the impact of availability of insurance benefits on health care decisions and outcomes. The model predicts that a pet owner whose benefits will renew in the next period will be more likely to treat. We find that the availability of insurance benefits does affect spending behavior. Young dogs, ages 2 to 5, receive nearly one extra vet visit on average over the next 6 months if they are diagnosed late in their policy term. They also receive more medical care as indicated by higher spending over the next year, concentrated in the first 3 months. These differences are apparent only for young dogs, however. Old dogs, ages 6 to 9, do not experience any spending boost from a late-in-term diagnosis. Very old dogs, ages 10 to 12, actually experience a dip in spending over subsequent months if they are diagnosed late in the policy term.

This finding tells us that pet health care decisions are largely dependent on the age of the dog. Pet owners are more likely to ramp up spending if their dog is still young. We attribute this difference to the likelihood that treatment will be successful, since older dogs have higher death rates even conditional on amount of treatment. While we see effects on health care decisions, these effects do not translate to different outcomes for the pet in any age group. We find no significant difference in death rates for any age group in the months following diagnosis.

Finally, we explore heterogeneous effects by cost of treatment for young dogs. The model predicts that more expensive treatments will have stronger effects. Consistent with this prediction, we find that the effect of a late diagnosis on spending is increasing in cost of treatment. The effect of a late diagnosis on pet death in the next 12 and 24 months is decreasing in the cost of treatment. This suggests that while we do not find an impact of a late diagnosis on pet outcomes overall, the most expensive treatments are indeed sensitive to the timing of benefits.

Apart from any extrapolation made between the results here and human health care, these pet health care results are interesting for what we learn about pets. About half of all US households (64 million) have at least one pet.[2] Dogs are the most common pet in the U.S. with an estimated 77 million dogs in total.[3] Given the importance of dogs in the modern lifestyle, our investments in their health care are likely of interest to many.

II Model

We propose a simple model of the behavior of pet owners who own a dog who becomes ill with cancer in period 1. The pet owners in our model each have a pet health insurance policy which will pay up to benefit level B of the cost of cancer treatment. Each pet owners' utility is H in periods in which the dog is healthy, $-C$ in periods in which the dog is sick, and 0 after the dog dies. The pet owner has three choices: (1) veterinary treatment which, with probability p, will result in the dog being healthy, (2) euthanization which will result in a utility level of 0 for the current and all future periods, and (3) do nothing. All dogs in our model, who have not been euthanized, die at the end of period 2.

The cancer treatment costs B in each period in which it is provided. The full amount of treatment is covered by the pet health insurance, but this is the maximum amount that insurance will cover until the term ends and the new term begins. For type 1 pet owners, the term began in period 1 and the new B in benefits will not be available until after period 2. For type 2 pet owners, a new B in benefits becomes available at the beginning of period 2. Clearly, it is better to be a type 2 pet owner because insurance will cover B cost of cancer treatment in period 1 and B cost of cancer treatment in period 2 if needed. For the type 1 pet owners, pet insurance will cover B cost of cancer treatment in either period 1 or period 2, not both. The timing of the new term is the only difference between type 1 and type 2 pet owners and we indicate this by $i = 1$ or $i = 2$. We denote the expected continuation

[2] The U.S. Census Bureau's American Housing Survey (2017) of 30,000 randomly selected households implies that 49 percent of households have at least one pet. The Simmons National Consumer Study (2018) survey of 25,000 randomly selected households suggests that 53 percent of households have a pet. Results from this survey are not released publicly, but the pet data was reported on by the Washington Post (Jan 31, 2019).

[3] Both the Simmons National Consumer Study (2018) and the American Veterinary Medical Association Survey (2016) estimate that 38 percent of U.S. households have one or more dogs.

utility as U_i and assume that the pet owners do not discount.

To solve the model, we start in period 2. If the dog was successfully treated in period 1, the continuation utility is H. If the dog was euthanized in period 1, the continuation utility is 0. If the dog was either not treated in period 1 or the treatment was unsuccessful, then the pet owner will need to choose between euthanization or treatment in period 2. We can rule out doing nothing as a choice because this would guarantee a period 2 continuation utility of $-C$ which is less than zero. The expected continuation utility depends on if the pet owner has insurance benefits B available. If the owner has insurance benefits, expected utility is given by:

$$E\left[U_i\right] = \begin{cases} 0 & \text{if euthanize} \\ pH + (1-p)(-C) & \text{if treat} \end{cases}$$

If the owner has no insurance benefits available (the policy began in period 1 and the owner exhausted the benefits due to an unsuccessful treatment in period 1), the expected utility is given by:

$$E\left[U_i\right] = \begin{cases} 0 & \text{if euthanize} \\ pH + (1-p)(-C) - B & \text{if treat} \end{cases}$$

If the owner has insurance benefits B available, the owner will choose to treat the pet as long as the probability p of successful treatment is greater than $\frac{C}{H+C}$, where C and H are both positive. If the owner has no insurance benefits available, p must be greater than $\frac{C+B}{H+C}$ for the owner to choose treatment. The interesting case is when p takes an intermediate value:

$$\frac{C}{H+C} < p < \frac{C+B}{H+C}.$$

which implies that the owner will only choose the treatment in period 2 if there are insurance benefits available.

Now consider the owner's choice in period 1. All pets in this period have cancer and all owners have insurance benefits B available. Owners of type 1 could choose to do nothing in period 1, saving their insurance benefits for treatment in period 2, but this provides lower expected utility than treating in period 1 because there is no advantage to waiting to treat. If we are in the interesting case where p takes on an intermediate value as described above, owners of type 1 would choose to euthanize in period 2 if the treatment is not successful, so we can derive that they will choose to treat in period 1 only if $p > \frac{C}{2H+C}$.

Pet owners of type 2 can use their insurance benefits to pay for treatment in period 1 and after the policy term ends, they will have an additional B in benefits to pay for treatment in period 2 if needed. We can show that type 2 pet owners will always choose treatment in period 1 if p is greater than the cutoff for treatment in period 2.[4] If p is greater than $\frac{C}{2H+C}$, but less than $\frac{C}{H+C}$ the type 2 pet owners will choose to treat in period 1 and euthanize in period 2. If p is greater than $\frac{C}{H+C}$ then type 2 pet owners will choose to treat in period 1 and if that treatment is unsuccessful, they will choose to treat again in period 2.

To summarize, if p is greater than $\frac{C+B}{H+C}$, both types will choose to treat in period 1 and both types would choose treat in period 2 if the treatment in period 1 is unsuccessful. If p is less than $\frac{C+B}{H+C}$ but greater than $\frac{C}{H+C}$, both types will choose to treat in period 1, but only type 2 pet owners would choose to treat in period 2.[5] If p is less than $\frac{C}{H+C}$ but greater than $\frac{C}{2H+C}$ then both types will choose to treat in period 1, but neither will choose to treat in period 2. Finally, if p is less than $\frac{C}{2H+C}$ neither type will choose to treat in period 1.

The implication of this model is that the timing of the pet health insurance term can have an important impact on the treatment decision. Those who have a pet diagnosed with a serious, but treatable, disease a short time before the end of the insurance term can "double up" by having B of veterinary expenses covered in the current term and another B covered in the next term. However, those who have a pet diagnosed with a serious disease soon after the beginning of the insurance term, will only be able to receive B of covered veterinary

[4]Type 2 pet owners will choose to treat in period 1 if $p > \frac{3C+3H+\sqrt{C^2+10CH+9H^2}}{2(C+H)}$. For $H > 0$ and $C > 0$, $\frac{C}{H+C} > \frac{3C+3H+\sqrt{C^2+10CH+9H^2}}{2(C+H)} > 0$.

[5]A larger B implies a greater range of p over which type 2 owners will choose to treat in period 2 but type 1 owners will not.

expenses in total.

III Data

We use claims-level administrative data from Nationwide Pet Insurance, the largest provider of pet health insurance policies in the United State.[6] It is important to note that only a small share of dogs in the U.S., about 2 percent in 2018, have a health insurance plan.[7] We observe claims from January 2009 through December 2019 for the universe of pet policy holders. For each claim we observe the date of treatment, a description of each treatment provided, the cost of the treatment as indicated on the veterinary bill, and the amount reimbursed by the insurance company.

For this study, we select a sample of dogs who were diagnosed with serious cancers between January 1, 2009 and July 31, 2017, so that we can observe a full 24-month period from date of diagnosis. We define serious cancers as cancers which are associated with a death rate 12 months after diagnosis that is greater than 70 percent.[8] We remove dogs who were diagnosed with a less serious cancer within the 2 years leading up to their serious cancer diagnosis, since these dogs were already sick. We further restrict the sample to dogs who are at least 2 years of age but no older than 12 at the time of diagnosis, and who have had an insurance policy for at least 1 year. This leaves us with a sample of 33,899 dogs.

We identify the date of diagnosis as the first treatment date in which a cancer-related medical claim was made. Determining if and when a dog dies from administrative insurance data involves some imputation. If there is a medical claim identifying pet death (i.e. claim description mentions death, euthanasia, and/or remains care), we use the date of this claim.

[6] Nationwide's market share is 35 percent. Pet health insurance does not include insurance policies that cover livestock, horses, or other farm animals. Market share is the percentage of gross written premiums as reported by the North American Pet Health Insurance Association State of the Industry Report (2018).

[7] North American Pet Health Insurance Association State of the Industry Report (2018) reports 1,538,000 active health insurance policies for dogs.

[8] These include: heart/pericardium neoplasia; thorax neoplasia; metastatic or infiltrative neoplasia; brain or spinal cord neoplasia; peritoneal neoplasia; osteogenic sarcoma; stomach neoplasia; hepatic neoplasia; lymphosarcoma; urethral neoplasia; small intestine neoplasia; peripheral vessels neoplasia; spleen neoplasia; leukemia; prostate neoplasia; and islet cell tumor.

If there is a cancellation of the policy, we use the date of cancellation, assuming that a cancellation when the pet has a serious medical condition indicates medical care ceased and the pet died. Likewise, if the policy is not renewed after the end of the policy term, and the policy term expired July 31, 2019 or earlier, we use the date that the term expired. Finally, if there is a denial of benefits that indicates pet death, we use the date of the medical claim associated with that denial.

Some imputations are also required for the cost of veterinary treatments. Claims where the cost of treatment is recorded as $0 are replaced with the median value by claim code and breed size.[9] We also replace cost of treatment values below the 10th percentile with the 10th percentile and values above the 90th percentile with the 90th percentile.

We also observe a variety of characteristics of the dog and the policy which we use as controls. These include indicators for female, 10 breed size categories (mixed and pure; great, large, medium, small, and toy), age at diagnosis, Census region, and plan type (including 26 different base plans, 10 wellness riders, and a cancer rider). We also use as controls total spending in the 12 months leading up to diagnosis, and month and year of diagnosis indicators. We show summary statistics for our full sample in Table 1.

End-of-Life Spending

In the human health care system, an important debate is the extent to which end-of-life spending is a large and growing share of overall medical spending (Melberg, 2018). Among other trends, researchers have noted that end-of-life medical care declines with age (e.g., Lubitz, Beebe, and Baker, 1995; Kwok, Semel, Lipsitz, Bader, Barnato, Gawande, and Jha, 2011).

We report patterns in end-of-life spending for our sample in Figures 1 and 2.[10] Of the 33,899 in our sample, 31,484 die before the end of the sample period, so we consider end-

[9]For a small number of cases where that claim code and breed size cell is empty, we replace it with the median value for the claim code.

[10]For tables showing these trends, see Section A.1.

of-life spending for these decedents. Overall, nearly $\$4,000$ or about 40 percent of lifetime medical spending takes place in the last 12 months of life. Pet owners spend less during the last 12 months of life if their pet is older, and spend less upon diagnosis for their older pets.

End-of-life spending also increases over time in our sample, from under $\$3,300$ in 2009 to over $\$4,500$ in 2017. While this may be connected to an overall increase in the cost of medical care, this spending as a share of lifetime spending also increases from 36 to 42 percent during these years.

The Role of Age in Probability of Successful Treatment

In the model, given that the treatment is expensive enough to prohibit at least some pet owners from treating, the decision to treat is increasing in the probability that the treatment will be successful. We first demonstrate that the probability of successful treatment is conditional on age. We estimate the following:

$$Death_{i,t} = \alpha_0 + \alpha_1 Old_i + \alpha_2 VeryOld_i + \alpha_3 Spending_{i,t} + \gamma X_i + \epsilon_i \tag{1}$$

where $Death_{i,t}$ is an indicator for death of dog i during time horizon t. Dogs are divided into three age groups: Young (ages 2-5), Old (ages 6-9), and Very Old (ages 10-12). We control for a variety of factors in the matrix X_i, including plan type, breed type and size, Census region, cumulative spending in the 12 months before diagnosis, month and year of diagnosis, and term week of diagnosis. The effect of treatment is captured by the coefficient on log spending, α_3.

We show the results in Table 2. While higher spending is associated with a higher death rate in the very short term (Column 1), for most time horizons higher spending is associated with lower death rates. In Column 2, we see that a 100 percent increase in spending in the first 3 months is associated with a 7.5 percentage point reduced likelihood of death in those months.

However, even conditional on treatment amount, the age group of the dog plays an important role in the likelihood of survival. In Column 2, we see that old dogs have a 9 percentage point higher death rate in the first 3 months, and very old dogs have a 13.2 percentage point higher death rate. This result establishes that age affects the probability of successful treatment.

Next, we show that pet owners respond by treating older dogs less. We estimate the following:

$$Spending_{i,t} = \alpha_0 + \alpha_1 Old_i + \alpha_2 VeryOld_i + \gamma X_i + \epsilon_i \tag{2}$$

where $Spending_{i,t}$ is log spending for dog i during time horizon t. We show the results in Table 3. In Column 4, we see that in the 12 months following diagnosis, old dogs receive 12.1 percent less medical treatment than young dogs, and very old dogs receive 26.8 percent less.

The conclusion from this analysis is that (1) age affects the probability that treatment will be successful, and (2) the probability of success plays a role in the decision to treat the pet. For the remainder of the analysis, where we explore the impact of the timing of benefit renewal, we hold this probability fixed by analyzing each age group separately. Given the importance of age, we add indicators for age within each age group, and age by breed size category interaction terms as controls.

IV Estimation Strategy

All policies in our sample have a term length of 12 months. Unlike human health care policies, which are highly seasonal, the Nationwide pet policies have start dates throughout the calendar year.[11]

[11] A small group of policyholders sign up through a group program, indicated as "group program payroll" in the "origination" variable. This group, representing about 20 percent of the policy-term observations, is disproportionately more likely to have policy start dates in December and January and are removed from

We rely on the assumption that cancer is a random shock that arrives independently of the month of term. Some dogs will be diagnosed toward the beginning of their policy term, so that there are many months until their benefits renew. Other dogs will be diagnosed toward the end of their policy term, giving their owners the option to spend their cancer benefits for the current term now, and the benefits for the next term in the near future. This means dogs diagnosed toward the end of the term have the possibility of "doubling-up" on benefits over the course of a few months.

We compare dogs who are diagnosed in weeks 5-16 (months 2-4) of their policy term compared to those who are diagnosed in weeks 41-53 (months 10-12) of their policy term. We do not include dogs diagnosed in month 1 of their policy term because the high numbers of vet visits during this month may be associated with a biased sample of diagnoses uncovered during routine checkups. As shown previously, pet owners make health care decisions differently depending on pet age therefore we stratify our analysis to different age groups. Descriptive statistics for this sample of early-term and late-term diagnosis dogs are reported in Table 4.

We are interested in the effect of a late diagnosis on spending, number of vet visits, and pet death over the subsequent months. Specifically, we estimate the following:

$$Y_i = \beta_0 + \beta_1 LateDiagnosis_i + \gamma X_i + \epsilon_i \tag{3}$$

where Y_i refers to outcome Y for pet i, β_0 is a constant, γ is a vector of coefficients on control matrix X_i, and ϵ_i is an error term. β_1 is the coefficient of interest, representing the causal impact of a late term diagnosis on outcome Y.

the data.

V Results: Effects of Benefit Renewal

Young Dogs

We report the main set of results for young dogs in Table 5. In each regression, we include the full set of controls. Each column shows the effect of a late diagnosis on the outcome over a different time horizon, ranging from 1 to 24 months. Starting with Panel A, we see that dogs diagnosed late in the term do experience an increase in spending over subsequent months. This suggests that owners are "doubling-up" on benefits by spending both current and next term benefits. In Panel B, we also see an increase in the number of vet visits by nearly one third of a visit during the first month, and nearly a full extra visit over the next six months. Consistent with the model, this is evidence that the presence of future benefits results in greater health care spending.

Despite evidence for increased medical care for these pets, we do not find any evidence that these pets are better off in terms of mortality. In Panel C, we see that later diagnosed pets are not less likely to die in the subsequent months. This result is reminiscent of findings elsewhere that the very high spending on human health care in the U.S. is not associated with better health outcomes.

Old Dogs

In Table 6, we repeat the analysis on older dogs, ages 6 through 9 at time of diagnosis. Here we see that these pets do not benefit from increased medical spending by their owner when they are diagnosed late in the policy term. This is consistent with the model predicting that pet owners will not be sensitive to benefit renewal if the likelihood of success is too low.

Curiously, late diagnosed dogs in this age group are less likely to die during the 12 and 24 month time horizons, despite no evidence of changes to medical care responses by the owner.

Very Old Dogs

For very old dogs, ages 10 to 12 at time of diagnosis, we actually find that late in term diagnoses are associated with less spending over the subsequent months. We report these results in Panel A of Table 7. It is possible that these pet owners are discouraged by the diagnosis and choose not to renew their policies, resulting in less spending in subsequent months. This is not associated with fewer vet visits, however, or any differences in ultimate outcomes, shown in Panels B and C of Table 7. It is possible that there is a divide between pet owners who have zero visits because they do not renew their policies and those who increase their number of visits, and these opposing effects cancel each other out.

Common across all three age groups is that later diagnosed pets do not have any differences in the likelihood of death. This is evidence that increased medical spending is not associated with a longer lifespan for the dog.

Expensive Treatments

Another prediction from the model is that more expensive treatments will have larger effects. In this final section, we interact the effect of a late diagnosis with the average cost of treatment.[12] We focus on young dogs since this group is associated with the strongest responses by pet owners, as shown above.

We report the results in Tables 8 through 10. Treatment cost is normalized to mean 0 with a standard deviation of 1. In Table 8, we see that more expensive treatment is unsurprisingly associated with higher spending across all time horizons. We also see that spending is even higher if the dog is diagnosed late in the policy term. In Column 4, we see that a 1 standard deviation increase in treatment cost is associated with a 16.7 percent increase in spending over the 12 months following diagnosis for dogs diagnosed early in the term, but a 20.9 percent increase in spending for late diagnosed dogs. Likewise, in Table 9,

[12]We calculate average cost of treatment by diagnosis as median spending during the 12 months following diagnosis.

we see that cost of treatment is also associated with more vet visits for late diagnosed dogs.

Finally, in Table 10, we explore the impact of treatment cost on death. While more expensive treatments are associated with lower initial death rates (Column 1), these treatments are associated with higher likelihood of death over the next year. These effects are attenuated, however, if the dog is diagnosed late in the policy term. Treatment cost is less prohibitive in cases where the dog is diagnosed late, since the pet owner is able to double-up on the benefits from the following term. As a result, these dogs are more likely to survive.

VI Discussion and Conclusion

This paper provides evidence that pet owners are sensitive to changes in insurance benefits when making health care decisions for their pets. Furthermore, pet owners take into account the age of the pet when responding to a serious cancer diagnosis. Owners spend less on older dogs with the same cancer diagnosis, as these dogs are less likely to survive. Finally, we do not find any evidence that these health care decisions have a significant impact on the longevity of the pet. The exception to this is for the most expensive cancer treatments, where the marginal impact of treatment cost on death is attenuated in the 12 and 24 month time horizons when dogs are diagnosed late in their policy term.

While there are many differences between pet health insurance and human health insurance, there is something to be learned from pet health trends.

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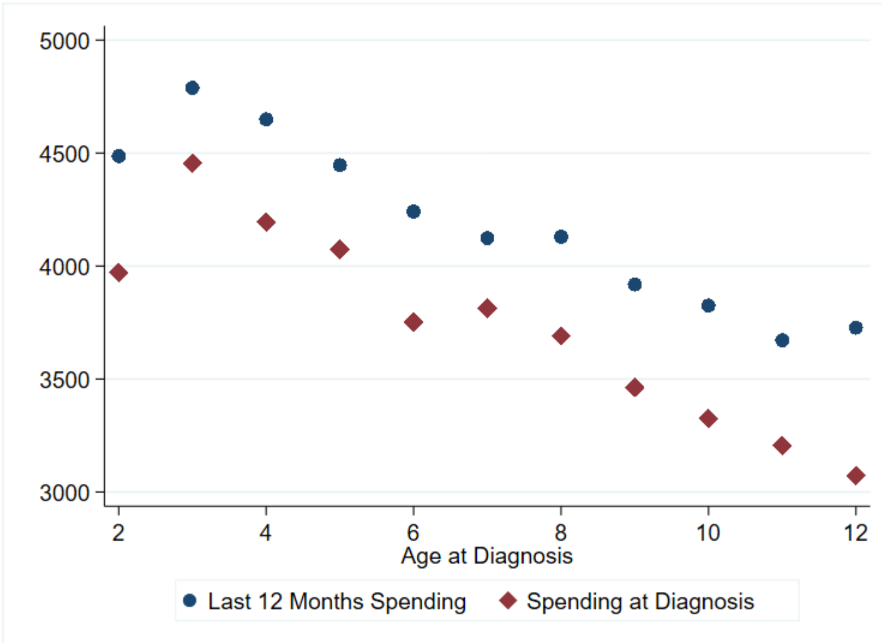
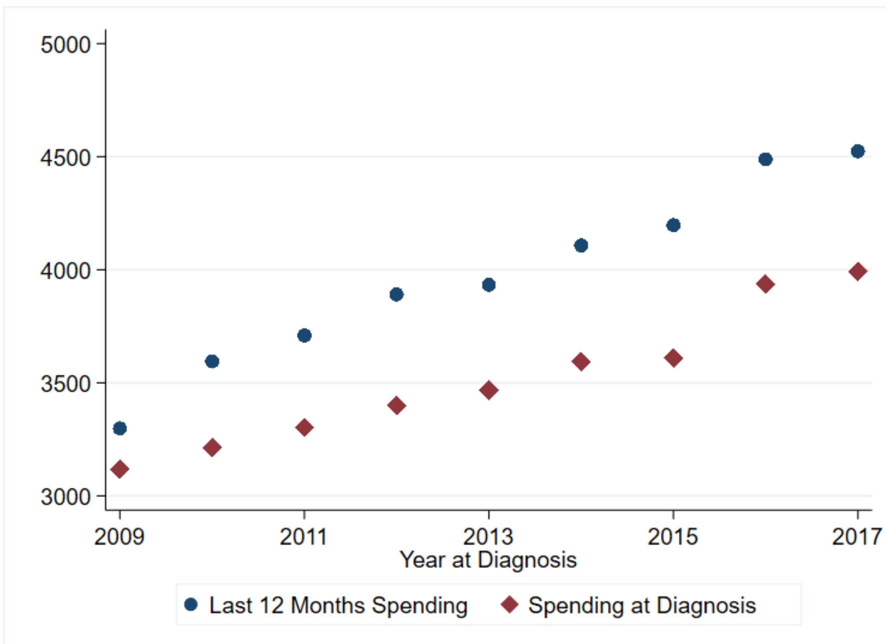
Figures and Tables

Figure 1: End-of-Life and Post-Diagnosis Spending by Age at Diagnosis



Notes - Last 12 Months Spending is mean end-of-life spending for the 31,484 dogs in our sample who died during the sample period. Spending at Diagnosis is mean spending during 12 months following diagnosis for the 33,899 dogs in our sample. Y-axis is US Dollars.

Figure 2: End-of-Life and Post-Diagnosis Spending by Year of Diagnosis



Notes - Last 12 Months Spending is mean end-of-life spending for the 31,484 dogs in our sample who died during the sample period. Spending at Diagnosis is mean spending during 12 months following diagnosis for the 33,899 dogs in our sample. Y-axis is US Dollars.

Table 1: Descriptive Statistics, Full Sample

	Mean (1)	St. Dev. (2)	Min. (3)	Max. (4)
Early Diagnosis Share	0.23	0.42	0.00	1.00
Late Diagnosis Share	0.22	0.41	0.00	1.00
Mean Log Spending Next 3 Months	7.58	0.81	3.69	10.60
Mean Total Visits Next 3 Months	3.32	2.97	1.00	26.00
Death Rate Next 3 Months	0.56	0.50	0.00	1.00
Mean Age at Diagnosis	8.69	2.29	2.00	12.00
Share Female	0.45	0.50	0.00	1.00
Mean Total Spending 12 Months Prior to Diagnosis	1013.37	1382.90	0.00	38974.34
Mean Year of Diagnosis	2013.14	2.39	2009.00	2017.00
Mean Month of Diagnosis	6.40	3.43	1.00	12.00
Observations	33,899	33,899	33,899	33,899

Table 2: Death Rates by Age Group, Conditional on Treatment

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
Old Dogs (Ages 6-9)	0.095***	0.093***	0.078***	0.042***	0.041***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.007)
Very Old Dogs (Ages 10-12)	0.149***	0.132***	0.111***	0.075***	0.085***
	(0.010)	(0.010)	(0.009)	(0.008)	(0.007)
Log 1-Month Spending	0.017***				
	(0.003)				
Log 3-Month Spending		-0.075***			
		(0.003)			
Log 6-Month Spending			-0.113***		
			(0.003)		
Log 12-Month Spending				-0.110***	
				(0.003)	
Log 24-Month Spending					-0.088***
					(0.002)
Observations	33,899	33,899	33,899	33,899	33,899

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Omitted Category is Young Dogs, Ages 2-5. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, calendar month of diagnosis indicators, and a term week of diagnosis control. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 3: Effect of Age on Spending Behavior After Cancer Diagnosis

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
Old Dogs (Ages 6-9)	-0.000	-0.058***	-0.097***	-0.121***	-0.131***
	(0.016)	(0.015)	(0.015)	(0.016)	(0.017)
Very Old Dogs (Ages 10-12)	-0.096***	-0.196***	-0.241***	-0.268***	-0.294***
	(0.016)	(0.016)	(0.016)	(0.017)	(0.018)
Observations	33,899	33,899	33,899	33,899	33,899

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Omitted category is Young Dogs, Ages 2-5. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, calendar month of diagnosis indicators, and a term week of diagnosis control. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 4: Descriptive Statistics, Regression Sample

	Young (2-5 yrs) (1)	Old (6-9 yrs) (2)	Very Old (10-12 yrs) (3)
Late Diagnosis Share	0.525 (0.50)	0.510 (0.50)	0.435 (0.50)
Mean Log Spending Next 3 Months	7.721 (0.85)	7.640 (0.80)	7.501 (0.79)
Mean Total Visits Next 3 Months	4.383 (3.79)	3.419 (3.03)	3.034 (2.72)
Death Rate Next 3 Months	0.453 (0.50)	0.565 (0.50)	0.596 (0.49)
Mean Age at Diagnosis	4.156 (0.95)	7.802 (1.06)	10.847 (0.80)
Share Female	0.415 (0.49)	0.437 (0.50)	0.484 (0.50)
Mean Total Spending 12 Months Prior to Diagnosis, USD	862.731 (1259.27)	974.703 (1322.47)	1113.827 (1427.75)
Mean Year of Diagnosis	2012.868 (2.34)	2013.163 (2.37)	2013.385 (2.34)
Mean Month of Diagnosis	6.427 (3.43)	6.345 (3.41)	6.423 (3.42)
Observations	1,524	7,618	6,171

Table 5: Effect of Late-in-Term Cancer Diagnosis on Spending, Vet Visits, and Likelihood of Death, Young Dogs (Ages 2-5)

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
			Panel A. Spending		
Late Diagnosis	0.080*	0.124***	0.127***	0.092*	0.057
	(0.047)	(0.047)	(0.049)	(0.048)	(0.049)
			Panel B. Vet Visits		
Late Diagnosis	0.314***	0.631***	0.945***	0.914**	0.779
	(0.099)	(0.211)	(0.320)	(0.414)	(0.539)
			Panel C. Death		
Late Diagnosis	0.016	0.032	0.027	0.015	0.028
	(0.026)	(0.027)	(0.027)	(0.025)	(0.023)
Observations	1,524	1,524	1,524	1,524	1,524

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, pet age at diagnosis indicators, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), pet age by breed size category interaction terms, 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, and calendar month of diagnosis indicators. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 6: Effect of Late-in-Term Cancer Diagnosis on Spending, Vet Visits, and Likelihood of Death, Old Dogs (Ages 6-9)

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
			Panel A. Spending		
Late Diagnosis	0.017	0.004	-0.002	-0.015	-0.018
	(0.019)	(0.019)	(0.019)	(0.020)	(0.021)
			Panel B. Vet Visits		
Late Diagnosis	0.030	0.018	0.058	-0.078	-0.104
	(0.036)	(0.071)	(0.103)	(0.140)	(0.196)
			Panel C. Death		
Late Diagnosis	-0.001	0.001	-0.008	-0.028***	-0.024***
	(0.012)	(0.012)	(0.011)	(0.010)	(0.009)
Observations	7,618	7,618	7,618	7,618	7,618

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, pet age at diagnosis indicators, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), pet age by breed size category interaction terms, 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, and calendar month of diagnosis indicators. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 7: Effect of Late-in-Term Cancer Diagnosis on Spending, Vet Visits, and Likelihood of Death, Very Old Dogs (Ages 10-12)

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
			Panel A. Spending		
Late Diagnosis	-0.029	-0.035*	-0.033	-0.047**	-0.058**
	(0.021)	(0.020)	(0.021)	(0.021)	(0.023)
			Panel B. Vet Visits		
Late Diagnosis	0.060	0.092	0.146	0.045	-0.083
	(0.037)	(0.070)	(0.104)	(0.146)	(0.202)
			Panel C. Death		
Late Diagnosis	-0.010	0.007	0.013	-0.002	0.000
	(0.013)	(0.013)	(0.012)	(0.011)	(0.009)
Observations	6,171	6,171	6,171	6,171	6,171

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, pet age at diagnosis indicators, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), pet age by breed size category interaction terms, 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, and calendar month of diagnosis indicators. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 8: Effect of Late-in-Term Cancer Diagnosis on Spending, Young Dogs (Ages 2-5), Heterogeneous Effects by Cost of Treatment

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
Late Diagnosis	0.083*	0.128***	0.132***	0.097**	0.062
	(0.047)	(0.046)	(0.048)	(0.047)	(0.048)
Treatment Cost	0.087***	0.147***	0.173***	0.167***	0.155***
	(0.032)	(0.032)	(0.033)	(0.033)	(0.033)
Late Diagnosis × Treatment Cost	0.011	0.022	0.030	0.042	0.052
	(0.045)	(0.044)	(0.045)	(0.045)	(0.045)
Observations	1,524	1,524	1,524	1,524	1,524

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Interaction term is median 12 month spending on treatment for cancer diagnosis, normalized to mean 0 standard deviation 1. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, pet age at diagnosis indicators, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), pet age by breed size category interaction terms, 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, and calendar month of diagnosis indicators. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 9: Effect of Late-in-Term Cancer Diagnosis on Vet Visits, Young Dogs (Ages 2-5), Heterogeneous Effects by Cost of Treatment

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
Late Diagnosis	0.323***	0.654***	0.977***	0.951**	0.817
	(0.097)	(0.206)	(0.313)	(0.406)	(0.532)
Treatment Cost	0.333***	0.822***	1.133***	1.301***	1.296***
	(0.067)	(0.143)	(0.217)	(0.282)	(0.369)
Late Diagnosis × Treatment Cost	-0.017	0.041	0.205	0.363	0.561
	(0.092)	(0.197)	(0.299)	(0.387)	(0.508)
Observations	1,524	1,524	1,524	1,524	1,524

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Interaction term is median 12 month spending on treatment for cancer diagnosis, normalized to mean 0 standard deviation 1. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, pet age at diagnosis indicators, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), pet age by breed size category interaction terms, 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, and calendar month of diagnosis indicators. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

Table 10: Effect of Late-in-Term Cancer Diagnosis on Death, Young Dogs (Ages 2-5), Heterogeneous Effects by Treatment Cost

	(1) 1 Month	(2) 3 Months	(3) 6 Months	(4) 12 Months	(5) 24 Months
Late Diagnosis	0.015	0.032	0.027	0.016	0.029
	(0.026)	(0.027)	(0.027)	(0.025)	(0.023)
Treatment Cost	-0.046***	0.006	0.022	0.047***	0.055***
	(0.018)	(0.019)	(0.019)	(0.018)	(0.016)
Late Diagnosis × Treatment Cost	0.006	-0.051*	-0.062**	-0.042*	-0.037*
	(0.024)	(0.026)	(0.026)	(0.024)	(0.022)
Observations	1,524	1,524	1,524	1,524	1,524

Notes - Each column refers to 1, 3, 6, 12, and 24 month time horizons from date of diagnosis. Interaction term is median 12 month spending on treatment for cancer diagnosis, normalized to mean 0 standard deviation 1. Controls include 26 plan indicators, 10 wellness rider indicators, a cancer rider indicator, pet age at diagnosis indicators, 10 breed size category indicators (pure and mixed; great, large, medium, small, and toy), pet age by breed size category interaction terms, 4 Census region indicators, cumulative spending during 12 months prior to diagnosis, calendar year of diagnosis indicators, and calendar month of diagnosis indicators. $*p \leq 0.10, **p \leq 0.05, ***p \leq 0.01$

A Appendix

A.1 End-of-Life Spending Patterns by Age and Year

In Tables 11 and 12 we report some statistics on end-of-life spending by age and year for dogs in our sample.

Table 11: Spending Patterns by Age at Diagnosis

	Last 12 Months Spending		Last 12 Months Spending, Share		First 12 Spending		First 12 Months Spending, Full Sample	
	mean (1)	st. dev. (2)	mean (3)	st. dev. (4)	mean (5)	st. dev. (6)	mean (7)	st. dev. (8)
2	4486.63	3871.09	0.63	0.28	4103.92	3728.30	3970.47	3693.59
3	4788.84	4047.29	0.60	0.27	4554.25	4129.64	4455.73	4006.89
4	4649.80	4072.49	0.55	0.24	4211.44	3625.88	4195.07	3678.86
5	4446.72	3728.47	0.52	0.24	4095.77	3683.28	4073.91	3615.21
6	4241.56	3696.45	0.47	0.21	3708.26	3349.09	3751.74	3403.71
7	4123.94	3619.04	0.44	0.21	3755.84	3500.51	3813.82	3501.81
8	4129.50	3647.24	0.41	0.19	3673.98	3529.48	3691.58	3501.87
9	3918.54	3422.73	0.39	0.18	3426.75	3280.63	3463.77	3290.27
10	3825.47	3434.50	0.36	0.17	3273.93	3266.11	3325.98	3277.99
11	3671.68	3091.46	0.33	0.16	3149.56	3002.78	3205.65	3035.13
12	3727.19	3513.39	0.31	0.15	3048.74	3111.44	3072.47	3108.58
Total	3983.01	3520.05	0.40	0.20	3484.40	3350.51	3525.44	3357.05
Obs.	31,484		31,484		31,484		33,899	

Notes - Columns show mean and standard deviation of each variable. Last 12 Months Spending is spending during the last 12 months of life. Last 12 Months Spending, Share is this end-of-life spending as a share of total lifetime spending on the pet's health care. First 12 Months Spending is spending during the first 12 months upon diagnosis. Share of lifetime spending in Columns (3) and (4) uses some imputed annual spending for cases where the dog does not have insurance for every year of life. To impute, we use median annual claims for pre-diagnosis dogs within the same breed size/breed category/gender/age cell as the annual claim for any missing dog/year observation.

Table 12: Spending Patterns by Year of Diagnosis

	Last 12 Months Spending		Last 12 Months Spending, Share		First 12 Months Spending		First 12 Months Spending, Full Sample	
	mean (1)	st. dev. (2)	mean (3)	st. dev. (4)	mean (5)	st. dev. (6)	mean (7)	st. dev. (8)
2009	3298.74	3048.75	0.36	0.19	3124.00	2782.78	3118.08	2776.60
2010	3594.35	3204.45	0.39	0.19	3229.24	2981.29	3213.86	2958.61
2011	3709.64	3185.78	0.39	0.19	3301.91	3066.80	3303.17	3058.99
2012	3891.07	3283.37	0.39	0.19	3405.94	3168.81	3400.92	3159.73
2013	3933.16	3412.79	0.39	0.20	3449.91	3252.07	3467.48	3278.68
2014	4107.77	3482.87	0.40	0.20	3593.28	3389.95	3592.60	3371.41
2015	4197.53	3780.65	0.41	0.21	3577.89	3606.52	3609.81	3547.78
2016	4489.28	4045.94	0.42	0.22	3844.71	3861.90	3937.31	3842.97
2017	4524.03	3916.74	0.42	0.22	3775.23	3759.60	3992.00	3805.47
Total	3983.01	3520.05	0.40	0.20	3484.40	3350.51	3525.44	3357.05
Obs.	31,484		31,484		31,484		33,899	

Notes - Columns show mean and standard deviation of each variable. Last 12 Months Spending is spending during the last 12 months of life. Last 12 Months Spending, Share is this end-of-life spending as a share of total lifetime spending on the pet's health care. First 12 Months Spending is spending during the first 12 months upon diagnosis. Share of lifetime spending in Columns (3) and (4) uses some imputed annual spending for cases where the dog does not have insurance for every year of life. To impute, we use median annual claims for pre-diagnosis dogs within the same breed size/breed category/gender/age cell as the annual claim for any missing dog/year observation.