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ABSTRACT

Provider Responses to the Expansion of Public Subsidies in Healthcare: The Case of Oral Chemotherapy Treatment in Australia

We examine provider responses to the expansion of public subsidies in 2015 for oral chemotherapy treatment, in a health system where providers were free to determine their own prices. Oral chemotherapy treatment was known to have similar efficacy to its traditional intravenous alternative and was preferred by patients for its at-home administration. However, from a policymaker's perspective, the potential for misalignment between patient and provider preferences was significant given the shift to full reimbursement for the oral chemotherapy medication but no change in fee-for-service payments for associated chemotherapy services. Under this scenario, a shift away from traditional intravenous chemotherapy may entail reduced activity and revenues associated with infusions for providers, and we hypothesise that it may result in unintended policy consequences such as reduced take-up of oral chemotherapy or higher prices. We implement a difference-in-difference model using national administrative data on services provided, and chemotherapy medications prescribed, by providers to 1850 patients in New South Wales, Australia. Our estimates indicate that the subsidies expanded access to oral chemotherapy for newly eligible patients by 15 percentage points. However, prices charged by providers for an episode of care rose by 23 percent, driven mostly by increases in service volumes. The results illustrate the importance of understanding differential provider responses to policy changes in financial incentives.

JEL Classification: I11, I13, D04

Keywords: provider behavior, financial incentives, applied microeconomics

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1. Introduction

Choice of medical technology has long been linked to the existence of financial incentives and insurance mechanisms (Weisbrod, 1991; Chandra and Skinner, 2012). Studies show that changes in funding arrangements (e.g. reimbursement rates) can trigger adoption of technologies as wide-ranging as open heart surgery units and neonatal intensive care units in hospitals (Acemoglu & Finkelstein, 2008; Finkelstein, 2007) and magnetic resonance imaging devices in outpatient settings (Clemens, 2014). The impetus for the choice in technology is often acknowledged as cost containment. However, these studies have centred on health systems where regulated reimbursement rates mean that profit-maximising behaviour by any provider can only be examined in terms of reducing costs or adjusting service volumes, but not altering prices.

In this paper we contribute to the literature by examining provider behaviour in response to the introduction of public subsidies for oral chemotherapy medication in a unique system where provider prices for associated services are unregulated. In doing so, we provide new evidence on provider pricing behaviour in this context. The treatment is used for breast cancer, colon cancer, rectal cancer, head & neck cancer, neuroendocrine cancer and upper gastrointestinal cancer, amongst other diseases (NSW Government, 2022). It has become one of the most prescribed oral chemotherapy agents (Kettle, 2015) and during the COVID-19 pandemic it was encouraged as a means of ensuring physical distancing (Castro, 2020).

Using a large representative survey sample linked to national Medicare claims data with detailed pricing for every service delivered by individual providers, we implement a difference-in-difference approach to assess whether the policy objectives of improved patient access were met. Specifically, we test whether full patient reimbursement for the cost of the oral chemotherapy medication resulted in 1) a transition toward its use, away from the

traditional intravenous chemotherapy treatment, and 2) whether physicians adjusted the quantity and/or price of associated chemotherapy services demanded to mitigate resulting losses in activity and income. Our study is instructive in not only examining provider behaviour where prices are unregulated, but where patient preferences are known to play a small role compared to provider preferences for treatment, and where divergent financial incentives exist (see section 2.1 for details)..

Our difference-in-difference design compares changes in outcomes between our 'treatment group' of cancer patients newly eligible for subsidised oral chemotherapy treatment, to our 'control group' of breast cancer patients who experienced no change in eligibility (having gained subsidised access much earlier). To preview our results, we find a 15.4 percentage point increase in the probability of receiving oral chemotherapy treatment, and a 7.0 percentage point reduction in the probability of receiving traditional intravenous chemotherapy. We find also that overall prices charged during a 12-month episode of care rose by 22.7 percent.

The paper proceeds as follows. In the next section, we provide an overview of literature relevant to our study and describe the policy and clinical context. Section 3 provides a conceptual framework for our study. Section 4 sets out our empirical approach. Section 5 describes our data. We report results and robustness checks in Section 6, before providing a concluding discussion in Section 7.

2. Background

This paper is broadly situated in the literature examining the role of funding arrangements, and in particular on the impact of financial incentives on health provider behaviour. These studies have examined the ability of providers to potentially shift demand for medical services has been examined extensively in the literature on physician agency and supplier-induced demand (McGuire, 2000). These studies are concerned with the motivations

and behaviour of providers in a monopolistically competitive market where providers may be able to exploit their superior knowledge and privileged relationship with the patient to influence both the price and quantity of services demanded (McGuire, 2000). Research has shown that healthcare providers do act in part in their own self-interest, altering the level of healthcare use beyond what is clinically indicated in response to changes in reimbursement rates and models (Clemens et al. 2014; Gruber et al., 1999; Yip, 1998), the risk of malpractice litigation (Currie &MacLeod, 2008), as well as in the presence of system-wide incentives (Iizuka, 2012). Within cancer care for example, Jacobsen et al. (2006) found that although reimbursement levels did not affect providers' decision to administer chemotherapy, they were more likely to prescribe costlier chemotherapy regimens when more generously reimbursed.

The operation of such financial incentives is of central empirical interest in this study. As described in section 2.1, chemotherapy services are largely delivered on a fee-for-service basis in the Australian health system, with providers able to determine their own prices. Providers are paid for consultations and the administration of traditional intravenous chemotherapy treatment in clinic and hospital settings, and shifting patients to oral chemotherapy regimens results in fewer outpatient visits and hospitalisations (Lopez-Vivanco et al., 2017; Twelves et al. 2001; Cassidy et al. 2006; Douillard et al., 2007; Di Costanzo et al. 2008). This reduced resource use, relating to lower use of clinic and staff resources, will likely result in reduced provider revenues, for which they are not compensated. The potential for poorly aligned patient preferences and provider incentives is particularly great because the policy change of interest – the introduction of subsidies for the oral chemotherapy treatment – was isolated to the reimbursement of pharmaceutical costs, with no funding changes for the substantial chemotherapy services required in tandem. In addition, certain activities that occur during an intravenous treatment (e.g. patient education, monitoring and

communication) are not explicitly funded and without an associated payment under new treatments, these tasks will either be unfunded, included in another funded activity or not completed (de Raad et al., 2010). Consequently, these financial arrangements may act as incentives to retain the status quo favouring traditional intravenous chemotherapy and temper any switch to oral chemotherapy. *If* there is a switch to oral chemotherapy, we might observe providers adjusting service volumes or prices to mitigate any activity and income losses. This is the empirical focus of our study.

Oral chemotherapy treatment makes for an instructive case study of provider behaviour because it falls into a category of treatment which can be classified 'preference sensitive' (Wennberg, 2002; Chandra and Skinner, 2012). Under this taxonomy, the choice between oral and traditional intravenous treatment should be sensitive to patient preferences because it involves trade-offs between two equally valid treatment strategies. Studies have shown that the efficacy of oral chemotherapy is non-inferior when compared to traditional intravenous treatments (Cartwright, 2012; Price et al., 2013; Cutsem et al, 2004). While traditional intravenous chemotherapy treatment typically requires catheters, pumps for continuous infusion and hospital visits by the patient or home visits by medical staff, oral chemotherapy does not require intravenous administration, and provides the convenience of oral administration at home (Rosenberg et al., 2020). While some patients will always be treated using traditional intravenous chemotherapy due to uncommon adverse reactions to the oral chemotherapy regimen, preferences formed from prior experience, or being on a multi-drug regimen which involves at least one other intravenous medication, many patients will likely prefer the oral chemotherapy option. In a number of studies, patients cited preference for oral administration, convenience, travelling less, lower anxiety, not having to trouble carers and family and having a greater ability to perform other tasks as reasons for their preference for oral chemotherapy (Chionh et al.,2017; King et al.,2000; Rischin et al. 2000).

In theory, informed patients could make decisions on these trade-offs based on the best clinical evidence and their own preferences; in practice, choices will rely on medical recommendation due to the asymmetric information inherent to the healthcare market (Arrow, 1963). For example, in one survey of 5050 patient-clinician encounters which took place in cancer outpatient clinics, only 440 (8.7%) patient requests for medical intervention were made, the majority of which were for investigative tests or palliative treatment (Gogineni, et al, 2015). Studies examining variation in health resource use find that patient preferences do not play a significant role in determining variation in health care use (Anthony et al. 2009; Barnato et al., 2007, Baker et al. , 2014). Rather, supply-side factors including clinician beliefs and decision-making styles explain a more substantial level of variation in care and costs (Wennberg et al., 1982; Baker et al. 2014; Cutler et al., 2019; Song et al., 2010). In cancer care for example, one survey study of 1174 breast cancer patients found they were significantly more likely to receive chemotherapy treatment if their treating physician reported preferences for chemotherapy (Mandelblatt, et al.,2012). In another study of cancer patients for whom palliative treatment would be considered the standard for care and where patients exhibited strong preferences, enrolment in hospice care was instead most strongly predicted by provider characteristics (Obermayer et al., 2015). The implication for our study is that provider preferences might have relatively strong influence in the uptake of oral chemotherapy compared to patient preferences.

2.1 Australian setting

We focus on capecitabine, an oral anti-cancer treatment and its equivalent intravenous analogue known as 5-fluorouracil (5-FU). Capecitabine is an orally administered medication which is converted to 5-FU within the body. 5-FU can be administered directly via an intravenous infusion (Aguado, García-Paredes, Sotelo, Sastre, & Díaz-Rubio, 2014), and both capecitabine and 5-FU can be given as a solitary agent or in combination with other anti-

cancer treatments (Aparicio et al., 2020). In this paper, we refer to treatment with capecitabine and oral chemotherapy interchangeably; we also refer to treatment with 5-FU and traditional intravenous chemotherapy interchangeably.

In the Australian setting, medications are available to physicians to treat their patients once approval is granted by the Therapeutic Goods Administration (TGA) of Australia. However, reimbursement of the costs of a medication, and therefore access for most patients, is only available when it is listed for the appropriate indication on the Pharmaceutical Benefits Scheme (PBS) of the Australian government. Prior to PBS listing, patients must pay the full cost of their medication. There is no publicly available data on the cost to patients of medication prior to their listing on the PBS, as this information is commercial-in-confidence and contracted between the pharmaceutical companies and those who dispense and use the medication.

Capecitabine was first listed on the PBS in 1999 for the treatment of advanced metastatic breast cancer. This listing was expanded progressively to include breast cancer more broadly, colorectal cancer and oesophago-gastric cancer. In 2015, the PBS recommended that the use of capecitabine become unrestricted for all cancer types. This last PBS listing is the focus of this study, providing exogenous variation in treatment status and allowing us to identify the causal effect of moving to full reimbursement of medication costs.

There is typically little or no patient co-payment relating to the cost of most chemotherapy medications, as they are subsidised by the Commonwealth Government via the PBS. As at January 2015, the patient co-payment was capped at $37.70 and $6.10 Australian dollars for general and concessional[1] patients, respectively. These subsidies support greater patient access to chemotherapy medications, however, there are also a suite of services

[1] Patients are eligible for concessional healthcare benefits if they are assessed by the Australian Government as meeting income and assets tests (e.g. if they are pensioners or other welfare recipients).

associated with intravenous chemotherapy typically delivered in the outpatient setting during day visits (although some treatments may require inpatient treatment). These services, such as consultations and infusion services, are delivered in both public and private treatment centres on a fee-for-service basis in a setting where physicians are free to set their own fees, and are known to price discriminate by charging higher prices to patients known to have higher capacity to pay (Meliyanni. Johar, Mu, Van Gool, & Wong, 2017; Yu, van Gool, Hall, & Fiebig, 2019). Such an unregulated pricing environment may act to reduce patient access to oral chemotherapy, despite subsidies for the associated medications.

Services associated with intravenous chemotherapy in Australia are remunerated by both the national Medicare system and by patients. While in theory patients are free to choose their provider, in practice they rely on medical recommendation and referral to an oncologist, with often little transparency in expected out-of-pocket costs (Cancer Council, 2020). The national Medicare system provides a rebate for out-of-hospital services, while the difference between the rebate and the physician's fee will form an out-of-pocket cost to the patient, paid directly to the physician. Where the physician charges exactly the Medicare rebate, there is no out-of-pocket cost to the patient. A systematic review of Australian cancer cost studies found that average patient out-of-pocket costs ranged from $877AUD for breast cancer to $11,077AUD for prostate cancer patients (Bygrave et al., 2021). There were no changes to this fee-for-service model of delivering chemotherapy services at the same time as the PBS moved to full reimbursement of the oral chemotherapy medication.

As discussed earlier, a shift to oral chemotherapy treatment likely entails a loss of in-clinic activity and associated provider revenues. This disconnect between the funding arrangements for the chemotherapy medications and services opens up the possibility of poorly aligned patient and provider preferences, with providers potentially able to influence demand for oral chemotherapy as well as the volume and prices of services.

The transition to oral chemotherapy treatment might entail not only a loss in clinic activity and income - there may also be a decline in attendant costs. In a micro-costing study in the same setting as this paper, Haywood et al. (2012) show that the cost of an episode of care for lung cancer patients (the largest group in our study to gain eligibility to subsidised oral chemotherapy) was strongly influenced by the number of visits required. Within each visit, substantial resource use was associated with nursing time for activities such as patient education and assessment, establishing intravenous access, administration of chemotherapy agents, monitoring and communication. It is plausible then that one consequence of greater uptake of oral chemotherapy and lower revenues could be lower costs, more efficient use of resources, or greater profitability. Indeed, if transitioning to oral chemotherapy reduces costs and frees up clinic resources for more profitable activities, it's possible that patient preferences and provider self-interest might be aligned in the decision to pursue oral chemotherapy. However, our ability to examine the impact of costs is limited by our available data.

3. Conceptual framework

Our conceptual framework for provider behaviour identifies competing factors which motivate a physician's behaviour and in turn drive our empirical strategy. We draw on provider behaviour models such as those outlined by Godager and Wiesen (2013) and Chen and Lakdalwalla (2017), which trace back to Ellis and McGuire (1986). We posit that a physician's utility function captures both selfish and altruistic motivations: selfish motivations include a physician's personal income (Rizzo & Zeckhauser, 2003), desire to mitigate litigation risk, and optimise time-use and convenience; altruistic considerations include the health of the patient, quality of treatment, patient preferences and satisfaction, as well as the patient's financial position (Liu and Ma, 2013; Chon´e and Ma, 2011; Ellis and McGuire, 1986; Godager and Wiesen 2013; Chen and Lakdalwalla, 2017).

We assume that providers choose the price and quantity of chemotherapy services which optimises their own utility function under conditions of monopolistic competition, consistent with Australia's unregulated fee-for-service setting as well as a long history of studies examining the complexity of the healthcare market and physician agency (McGuire, 2000; Gaynor, 2000; Dranove, Satterthwaite 1992; Frech 1996; Dranove, Satterthwaite 1999). A provider will choose to treat a patient with oral chemotherapy treatment if the utility of doing so exceeds the traditional intravenous chemotherapy treatment alternative. Within this framework, heterogeneity in provider motivation exists, with more altruistic providers weighing patient welfare more highly relative to more self-interested providers. More altruistic providers will optimally deliver care focused more strongly on patient benefit (e.g. lower prices), whereas a more self-interested provider will also weigh their own welfare highly (e.g. higher prices).

Based on this model of provider behaviour, the key research questions are: 1) whether there was a transition in treatment decisions towards oral chemotherapy treatment from traditional intravenous chemotherapy; and 2) if there is evidence of a switch, whether providers adjusted either their service volumes and prices to offset both changes in therapeutic needs and potential revenue losses. We anticipate that with the lower requirements for medical supervision of oral chemotherapy, physicians may alter their behaviour for both selfish and altruistic reasons. Selfish motivations may include increasing service volumes and/or increasing prices to stabilise personal income. Altruistic motivations may include increasing consultation services to better monitor patient health. As noted, these motivations will be heterogeneous across providers. Prior studies have shown that provider preferences most strongly predict choice of cancer treatment (Mandelblatt et al., 2012; Obermeyer et al., 2015), but also that provider responses to financial incentives are more

muted when treatment is less discretionary – as in cancer treatment – and the patient's marginal benefit of treatment is high (Clemens & Gottlieb, 2014).

Given what is known about patient benefit and preferences for oral chemotherapy, our hypothesis is that providers acted to support its uptake, but to also guard their self-interest by increasing possibly both service volumes and prices charged within an episode of care. We also hypothesise that heterogeneity in effects exists, with more altruistic providers less likely to increase prices or provide unnecessary services. We now turn to the empirical strategy to examine these outcomes more closely.

4. Empirical strategy

We implement a quasi-experimental, difference-in-difference framework to exploit the exogenous introduction of oral chemotherapy medication to the PBS. This approach allows us to compare outcomes between a treatment group – defined as patients who had a cancer type newly-eligible for subsidised treatment with oral chemotherapy, and a control group – defined as those whose eligibility for oral chemotherapy treatment did not change (breast cancer patients). We compare the change in outcomes between the treatment and control group, before and after the listing of the oral chemotherapy medication in 2015 (when it became unrestricted for all cancer types).

Our sample comprises 1850 episodes of chemotherapy treatment which commenced within the 22 months around the listing date of 2015 (22 months was selected to account for the end of our data period in December 2017). We defined an episode of chemotherapy as 12 months from the first date of supply of any chemotherapy medication. Patients were excluded if they had multiple cancers due to the complexity of care involved. We include only the first episode of chemotherapy for each patient to mitigate the possible impact of previous experience on treatment preferences and potentially outcomes

The key outcomes of interest relate to out-of-hospital services and supply of chemotherapy medications provided to these patients by their treating oncologists. We would expect, for example, that newly subsidised access to the oral chemotherapy medication might increase its supply. It may also reduce the number of infusion services and prescriptions for traditional intravenous treatment. Changes in the volume and price of consultations, as well as total costs, are dependent on whether we observe the expected uptake in oral chemotherapy. For example, a switch to oral chemotherapy use might entail more consultations to enable the physician to better monitor the patient. Alternatively, more consultations and higher prices may be induced to offset the physician's loss in income associated with fewer clinic visits and infusion services. However, if we do not observe a switch to oral chemotherapy, we would not expect any consequent changes in the volume or prices of services. Specific outcomes of interest include:

1. The extensive and intensive margin of both oral and intravenous chemotherapy treatment, as measured by supply of capecitabine and 5F-U, respectively.
2. The volume and price of intravenous infusion services per episode of care.
3. The volume and price of consultations per episode of care.
4. The total price charged per episode of care.

Figure 1 helps motivate our study by illustrating take-up of the oral chemotherapy drug in the raw monthly data. The figure shows differential changes in the use of oral chemotherapy over time. For patients newly eligible for oral chemotherapy treatment in 2015 ('treatment group'), on average 0.65% of patients in our sample were supplied the oral chemotherapy medication in the 12 months prior to its listing (black line). This proportion rose significantly to 3.06% on average in the 12 months following the listing. We observe also that the jump in access to oral chemotherapy occurred in December 2014, the month

following the announcement of its unrestricted PBS listing. For breast cancer patients ('control group'), the proportion was stable, falling slightly from 6.5% to 5.8% in the pre and post-listing periods (grey line). Figure 1 does not serve to demonstrate the underpinning parallel-trends assumption, which is conditional on covariates and cannot be inferred from the raw data in Figure 1 (Callaway & Sant'Anna, 2021). We provide supporting evidence for our identifying assumptions in Section 6.2.

Figure 1. Change in access to the oral chemotherapy medication

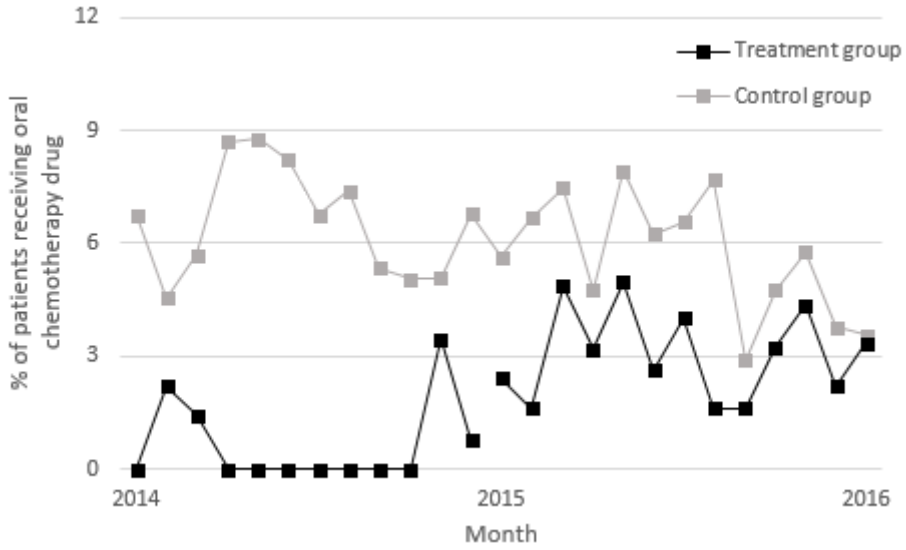

Figure 1 depicts monthly observations of the proportion of patients who accessed the oral chemotherapy medication in the 12 months before and after its unrestricted PBS listing. The 'treatment group' refers to patients with cancer types newly eligible for oral chemotherapy treatment, while 'control group' refers to breast cancer patients who had no change in eligibility.

We estimate the following model specification:

$$Y_{ijkt} = \boldsymbol{\beta_1 X_{it}} + \beta_2 D_t + \beta_3 D_j + \beta_4 D_t . D_j + \gamma_j + \delta_k + \varepsilon_{ijkt}$$

Here, *i* indexes individual patients, *j* indexes cancer type, and *k* indexes individual providers. Y_{ijkt} represents an outcome of interest relating to the patient's healthcare use, detailed below. The dummy variable D_t takes a value of 1 if the service or medication was provided after March 1 2015, and zero otherwise. The dummy variable D_j takes a value of 1

if the patient's cancer type was newly eligible for oral chemotherapy treatment and zero if the patient had breast cancer. γ_j represents fixed 'cancer' effects and captures time-invariant differences in outcomes between cancer types. The treatment group largely comprised patients with lung, pancreatic, prostate, melanoma, and ovarian cancers in both periods. δ_k represents provider fixed effects. The vector X_{it} represents patient-level socioeconomic and health characteristics which may influence healthcare use, and includes gender, age, marital status, level of education, income bracket, cultural/language background, whether or not the patient was working full-time, geographical location (major city or otherwise), and a geographically-based index of socioeconomic disadvantage. β_4 captures the effect of the new public subsidies on the use of oral chemotherapy and other outcomes of interest, and is the coefficient on the interaction term between D_t and D_j.

To identify cancer types, we employ the approach detailed in Goldsbury et al. (2019), which validated the use of hospital diagnosis codes in the same dataset as our study to identify diagnosis of cancer types. The hospital diagnosis codes, classified using the International Classification of Diseases 10th Edition (ICD10), were found to match over 90 percent of cases to the NSW Cancer Registry. ICD-10 codes for patients with subsidised access to oral chemotherapy treatment prior to 2015 included C50 for breast cancer, C15-C17 for oesophageal/gastric cancer and C18-C20 for colorectal cancer.

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Equation (1) was estimated using OLS for all outcomes except for changes in the extensive margin of receiving oral or intravenous chemotherapy treatment. For these outcomes, equation (1) was estimated using a probit model. Standard errors were clustered by cancer-type.

The key identifying assumption in our model is that trends in outcomes between the treatment and control groups would be the same in the absence of new subsidies for the oral chemotherapy medication. The assumption critically relies on the comparability of the two groups. The model addresses this to some extent by controlling for a range of observed characteristics, and also by implementing a form of fixed-effects estimation which 'differences away' patient-level, time-invariant unobserved factors (Angrist & Pischke, 2009). However, the model does assume that time effects are common across the treatment and control groups, and that the composition of both groups is stable before and after the 2015 listing. Our main concern then is that different cancer types may have experienced idiosyncratic shocks affecting diagnosis and treatment pathways, and that these might affect the comparability of our treatment and control groups. To interrogate this more closely, we implement validation checks, including:

1. Using an alternative control group of patients with haematological cancers, for which the oral chemotherapy medication, capecitabine, is ineffective.
2. Implementing a placebo model which tests for spurious effects. Drawing on Autor (2003), we replicate the model for the period between 2012 and 2016 (with March 2014 denoting a placebo reform). We expect to find no significant results as there were no significant policy changes during this period.
3. Restricting our model to female cancer patients only, to address concerns that our main control group of female only breast cancer patients may produce unobserved differences in outcomes arising from concordant or discordant gender pairings of patients and providers.

5. Data

We use data from the Sax Institute's 45 and Up Study, which comprises 267,153 non-institutionalised individuals aged 45 and over in the state of New South Wales (NSW) in

Australia. Participants completed a baseline questionnaire (between January 2006 and December 2009) and gave signed consent for follow-up and linkage of their information to administrative health databases. The sample comprises about 10 percent of the total NSW population aged 45 and over, and is representative of the population in terms of demographic characteristics including age, gender and marital status (Johar, Jones, Savage 2012), as well as a range of health risk factors (Mealing et al., 2010). The conduct of the 45 and Up Study was approved by the University of New South Wales Human Research Ethics Committee. This project received ethics approval from the UTS Human research ethics committee (UTS HREC REF NO. ETH18-2507).

The 45 and Up Study is linked to national administrative datasets, including the Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Scheme (PBS) claims data provided by the Commonwealth Department of Human Services. The MBS data records the service date and type, fee charged, benefit paid for services funded by Medicare. Salient to our study, the PBS data records the date of supply, and type of medication supplied, of any medicines subsidised by the PBS, including capecitabine, 5-FU and other chemotherapy medications. Although our sample is not representative of the provider population and we do not observe characteristics of the providers (e.g. age, gender, experience), workforce data shows that there were 148 medical oncologists in New South Wales in 2015; our sample captures 112 of these providers (NSW Ministry of Health, 2018).

Table 1 sets out the summary statistics for our treatment and control groups before and after the 2015 unrestricted listing of the oral chemotherapy medication. It shows the characteristics and key outcomes for cancer patients newly eligible for subsidised access to oral chemotherapy, compared to breast cancer patients who experienced no change in their eligibility. The difference-in-difference design relies on a 'parallel trends' assumption and does not require the treatment and control group to be 'matched' in observed covariates,

however it does assume that the composition of the treatment and control groups is stable before and after the unrestricted listing. The data in Table 1 shows this to be the case, with small changes in almost all observed characteristics. In addition, while there was heterogeneity in the cancer types comprising the treatment group, the top ten cancers formed around 84 percent of all episodes of care in the before and after periods, and predominantly comprised patients with lung, pancreatic, prostate, melanoma and ovarian cancers.

In our sample defined by cancer patients receiving any chemotherapy treatment, there were around 600 episodes of care in each of the before and after periods for the treatment group, compared to around 300 episodes in each period for the control group. The data shows that the proportion of newly eligible patients receiving oral chemotherapy treatment – specifically capecitabine – rose from 1 to 5%, while falling slightly for the control group. The proportion of treatment group patients receiving traditional intravenous chemotherapy – specifically, 5-FU – fell from 4 to 2%, while rising slightly for the control group. The number of infusion services rose slightly amongst treatment group patients compared to falls in the control group, while the number of consultation services were virtually unchanged for both groups. The total price charged for treatment group patients was stable, while a fall in overall price was observed for control group patients. We now turn to the regression results.

Table 1. Descriptive statistics

	Newly eligible in 2015		Breast cancer patients	
	Before listing	After listing	Before listing	After listing
% female	0.41	0.41	1.00	1.00
Average age	70.55	70.78	64.90	65.16
% Married/defacto relationship	0.74	0.78	0.70	0.71
Highest level of education				
Year 11 and below	0.38	0.33	0.37	0.29
At least Year 12	0.41	0.45	0.38	0.36
Bachelor degree and above	0.21	0.22	0.25	0.36
Geographical location				
Major city	0.56	0.50	0.57	0.59
Inner Regional	0.33	0.37	0.34	0.34
Outer Regional and remote	0.11	0.13	0.09	0.08
Income level				
Less than $30000 pa	0.34	0.34	0.30	0.23
$30000 to $69999 pa	0.31	0.29	0.25	0.27
At least $70000 pa	0.19	0.21	0.26	0.33
Did not disclose	0.16	0.17	0.19	0.17
Quintile of socioeconomic disadvantage				
Q1 (Most disadvantaged)	0.17	0.21	0.18	0.16
Q2	0.24	0.24	0.18	0.16
Q3	0.23	0.16	0.15	0.26
Q4	0.17	0.19	0.24	0.20
Q5 (Least disadvantaged)	0.20	0.20	0.24	0.21
Region of birth				
Australia/Oceania	0.80	0.79	0.84	0.80
North/West Europe	0.12	0.13	0.08	0.11
South/East Europe	0.04	0.03	0.02	0.05
North Africa/ Middle East	0.01	0.01	0.01	0.00
Southeast Asia	0.01	0.01	0.00	0.03
Northeast Asia	0.01	0.01	0.03	0.00
South/Central Asia	0.01	0.01	0.01	0.00
North America	0.00	0.00	0.00	0.00
South/Central America	0.00	0.00	0.01	0.00
Subsaharan Africa	0.02	0.01	0.01	0.00
% Concession cardholder[1]	0.64	0.64	0.51	0.45
% Employed full-time	0.23	0.24	0.30	0.41
Number of episodes (per patient per provider)	580	689	311	270
% receiving oral chemotherapy	0.01	0.05	0.08	0.06
% receiving traditional intravenous chemotherapy	0.04	0.02	0.12	0.14
Number of infusion services (per episode per provider)	6.9	7.3	8.8	8.2
Number of consultation services (per episode per provider)	5.7	5.6	5.5	5.1
Total charge (per episode per provider)	685	699	866	793

1. Concession cardholders are entitled to cheaper medical services and medicines. Eligibility is means-tested by the Australian Government.

6. **Results**

Our main results are set out in Tables 2 and 3 below, which detail the changes observed in the supply of chemotherapy medications, and the provision of chemotherapy services, respectively. Full regression results are available in the online appendix. The treatment effects reported in Table 2 show that the probability of receiving oral chemotherapy treatment increased by 15.4 percentage points following the rollout of subsidies in 2015. We also find a small and statistically significant increase in the number of scripts supplied of the oral chemotherapy medication. Although not entirely offsetting the greater uptake of oral chemotherapy, there was a 7.0 percentage point drop in the probability of traditional intravenous chemotherapy. We would not expect a direct substitution between oral and intravenous treatments, as chemotherapy regimens feature a cocktail of therapeutic agents, which may or may not include the specific and substitutable agents of interest here (capecitabine and its intravenous analogue, 5-FU). The coefficients on D_j, the dummy variable for group effects associated with episodes of care for newly eligible patients, indicated that overall these patients were less likely to be receiving oral chemotherapy treatment, and more likely to receive IV treatment.

Table 2. Changes in the supply of chemotherapy medications

OUTCOME	Probability of oral chemotherapy	Number of capecitabine scripts per episode	Probability of intravenous chemotherapy	Number of 5-FU scripts per episode
Treatment effect	0.154**	0.207**	-0.07***	-0.028
	(0.073)	(0.093)	(0.025)	(0.135)
D_t	-0.03***	-0.033	0.02***	-0.040
	(0.003)	(0.029)	(0.003)	(0.031)
D_j	-0.174**	-0.68***	0.38***	0.010
	(0.068)	(0.208)	(0.038)	(0.256)
Mean of treatment group outcome pre-2015	0.009	0.026	0.041	0.281
Observations	1,104	1,850	1,301	1,850
R-squared	0.20	0.22	0.21	0.35

The treatment effect for changes in the probability of oral or IV chemotherapy is reported as the average marginal effect from a probit model, and is measured by the supply of oral and IV chemotherapy medications capecitabine and 5-FU only. For other outcomes, the treatment effect is reported as the coefficient estimate β_4. All models are based on 12-month patient-provider episodes of care. All models include cancer-type and provider fixed effects. Standard errors clustered by cancer type in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Turning to changes in chemotherapy-related services, Table 3 presents results for the number of consultation and infusion services, as well as the prices charged for these services (using log scale for the price outcomes). We find evidence that for patients who received intravenous chemotherapy, the number of infusion services increased by 1.3 following the rollout of subsidies for oral chemotherapy. The volume of consultation services also showed a statistically significant but smaller increase of 0.7. The coefficient on D_t indicates that there has been a gradual decline over time in the number of infusion services provided, although the magnitude of this effect was small. However, our analysis of prices showed weak evidence that prices charged for infusion services rose by 2.1 percent following the 2015 change in subsidies. Most substantially, however, we find statistically significant evidence that the total price charged for all services in an episode of care were higher, on average, by 23 percent. One contributing factor to this result is that across the sample, the total price of an episode of care fell over time (coefficient on D_t); higher prices for patients newly eligible for oral chemotherapy were therefore measured relative to a falling time trend. We discuss potential mechanisms for this suite of changes in the next section.

Table 3. Changes in the provision of chemotherapy-related services

OUTCOME	Number of infusion services per episode	Price charged per infusion service	Number of consultation services per episode	Price charged per consultation service	Total price charged per episode
Treatment effect	1.332**	0.021*	0.667**	0.002	0.23***
	(0.610)	(0.011)	(0.294)	(0.010)	(0.047)
D_t	-0.654**	-0.02***	-0.55***	0.003	-0.16***
	(0.249)	(0.006)	(0.179)	(0.005)	(0.035)
D_j	-0.805	-0.031	-4.732*	-0.050	-1.07***
	(1.623)	(0.033)	(2.708)	(0.057)	(0.312)
Mean of treatment group outcome pre-2015	6.9	83.3	5.7	84.1	684.8
Observations	1,279	9,735	1,940	10,756	1,940
R-squared	0.26	0.81	0.27	0.76	0.33

Standard errors clustered by cancer type in parentheses. Fee outcomes are modelled on a log-scale basis. All outcomes are measured on a per patient-provider episode of care basis. Infusion and consultation services comprise those delivered by oncologists only. All models include cancer-type and provider fixed effects. *** p<0.01, ** p<0.05, * p<0.1

6.1 Mechanisms

In this sub-section, we explore alternative specifications which shed light on the mechanisms underpinning our baseline results. These results are presented in Table 4.

We first explore the possibility that the benefits of at-home administration of oral chemotherapy might fall heterogeneously on different patients.In our sample, 71 percent of patients also received an intravenous medication other than 5-FU. Patients who are receiving any intravenous chemotherapy will need to visit their treatment centre to receive infusions, which may minimise any benefits associated with at-home administration of capecitabine. We therefore present results from two subsamples of patients: 1) those who did not receive treatment with *any* intravenous chemotherapy medication (other than 5-FU, which is substitutable with oral chemotherapy), and therefore have greater incentive to switch to at-home treatment; and 2) those who were receiving at least one other intravenous chemotherapy treatment (which could not be substituted).

Table 4 shows stark results. Amongst patients with no other intravenous treatment, the uptake of oral chemotherapy, and transition away from intravenous treatment, was larger and

still statistically significant despite a much smaller sample (524 episodes of care). The probability of receiving oral chemotherapy treatment for this group rose by 27 percentage points, while falling commensurately for traditional intravenous treatment. Other results had standard errors too large to reach statistical significance.

By contrast, patients receiving any intravenous chemotherapy had more moderate changes in the likelihood of switching to oral chemotherapy (up 14 percentage points). However, there was significant evidence that these patients also received a higher volume of services (around 2 extra infusions and 1 extra consultation) and were overall charged 33 percent higher prices across their episode of care. Based on average values of $84.90 and $84.70 for infusion and consultation services, respectively, and $689.70 in total price for an episode of care for this group, the increase in service volumes roughly accounts for the higher overall price.

In terms of understanding the mechanisms, we interpret these changes as likely reflecting therapeutic need: the increase in infusion services, for example, is consistent with the possibility that patients who did not switch to oral chemotherapy were those who required more intensive intravenous treatment, although we did not have data on each patient's severity of disease to confirm this. The increase in consultation services may also reflect a greater need to monitor such patients. While it is possible that higher volumes of unnecessary services were used to compensate for reduced clinic activity, we did not find any other supporting evidence such as increases in the duration of consultation or infusion services. As noted, we found weak evidence that infusion service prices rose (and no evidence for a change in consultation prices). The overall fee increase in our baseline results was therefore driven by an increase in volumes, concentrated amongst those who required more clinic services. We do not find evidence to support our hypothesis of self-interested behaviour. While we did find significant increases in the charges for a heterogeneous suite of less

common services (including assessment and review consultations, telehealth consultations, and the use of medication delivery devices), we observed that the top three items billed by oncologists for both the treatment and control groups accounted for over 85% of all services in our sample.

We hypothesised that there are heterogeneous effects reflecting differences in the altruistic and self-interested motivations of different providers. While we do not have a direct measure of these motivations, we calculated an indirect, albeit blunt, measure. Based upon the distribution of fees charged for a single MBS consultation item commonly used by all providers, we defined 'high-charging' providers as those charging top quartile fees, and 'low-charging' providers as those charging in the bottom quartile, in the period prior to the policy reform. On average, a consultation with a high-charging doctor cost $107.96, compared to $69.62 at a low charging doctor. We present results for separate samples of high versus low charging providers in Table 4, using high-charging doctors as a proxy for those likely to act more in self-interest, and low-charging doctors as a proxy for those with stronger altruistic motives. We do not observe behaviour in the uptake of oral chemotherapy (as provider identifiers were not linked across MBS and PBS datasets), and therefore only present results on the volume and prices of chemotherapy services.

For low charging, and presumably more altruistic providers, we would expect a greater uptake in oral chemotherapy. Although we do not observe this directly, the results support this indirectly. The results showed a statistically significant increase of 2.0 consultations amongst low-charging doctors (from a base average of 4.63 consultations per episode of care), as well as an average 5.7 percent increase in consultation fees. Consequently, the total price for the episode of care rose significantly amongst low-charging doctors (51.8 percent from a base level of $548.19). A closer inspection of the services showed that both increases were due to an increase in both the volume and price of

multidisciplinary case conferencing services, where a team of clinicians across disciplines review the patient's history and needs, and plan their treatment path. These extra services were likely provided to improve patient monitoring during their at-home chemotherapy regimen. The attendant price increases, which for case conferencing are likely determined at the centre-level rather than by individual doctors, may be a response to income lost due to reduced clinic activity.

By contrast, for high-charging providers, the number of consultations decreased, although the result was not statistically significant. The results also showed a statistically significant decrease in the price for infusion services, although this is difficult to interpret because we are unable to link this analysis to changes in the use of intravenous chemotherapy.

Overall, we find suggestive evidence that altruistic (i.e. low charging doctors) responded to the rollout of subsidies for oral chemotherapy medications by increasing their consultation schedule and prices, likely as a response to greater uptake of oral chemotherapy and the associated loss of clinic income. We did not find evidence that high-charging doctors responded with highly self-interested behaviour. However, our inferences were limited by data limitations on how these high versus low charging doctors switched from intravenous to oral chemotherapy. We also acknowledge that our measure of altruism – high charging versus low charging providers, is at best an indirect and blunt measure, and unable to adequately capture true differences in provider altruism.

Finally, we examine the impact of announcement effects. The announcement of subsidies for oral chemotherapy occurred in in November 2014 (almost four months prior to implementation), and it is plausible that the announcement had an immediate impact on cancer treatment plans. Our test of these announcement effects implements our difference-in-

difference model with D_t equal to 1 if the episode of care commenced after November 30, 2014 (and zero otherwise). The results strongly support our baseline results with greater statistical significance across many outcomes, including stronger evidence that prices for infusion services increased slightly. Although reimbursement of medication costs did not commence until March 2015, it is plausible that providers and patients commenced oral chemotherapy treatment in the knowledge that a substantial proportion of costs over the course of an episode of care would be reimbursed.

Table 4. Alternative specifications

TREATMENT EFFECTS	Sample size	Probability of oral chemotherapy	Probability of traditional chemotherapy	Number of capecitabine scripts	Number of 5FU scripts	Price charged per infusion service	Number of infusion services	Price charged per consultation service	Number of consultations	Total price charged
Baseline	1,850	0.154**	-0.07***	0.207**	-0.028	0.021*	1.332**	0.002	0.667**	0.23***
		(0.073)	(0.025)	(0.093)	(0.135)	(0.011)	(0.610)	(0.010)	(0.294)	(0.047)
No other IV chemo	524	0.270**	-0.27***	0.673	-0.295	0.047	2.981	0.063*	-0.701	-0.174
		(0.130)	(0.095)	(0.550)	(0.407)	(0.038)	(4.648)	(0.033)	(1.439)	(0.235)
At least one other IV chemo	1326	0.14***	-0.09***	0.153*	-0.009	0.013	1.95***	0.000	0.95***	0.33***
		(0.043)	(0.030)	(0.086)	(0.114)	(0.013)	(0.581)	(0.014)	(0.339)	(0.071)
High-charging providers	368	-	-	-	-	-0.080**	0.368	-0.051	-1.61	0.092
						(0.037)	(2.206)	(0.032)	(1.101)	(0.2)
Low-charging providers	489	-	-	-	-	-0.005	0.849	-0.003	2.00***	0.518***
						(0.007)	(0.645)	(0.012)	(0.472)	(0.108)
Announcement date effects	1977	0.11***	-0.09***	0.135**	-0.211**	0.014**	1.98***	0.006	0.636**	0.25***
		(0.026)	(0.026)	(0.055)	(0.098)	(0.009)	(0.374)	(0.017)	(0.194)	(0.074)

"No other IV chemo" replicates the base model on a subsample of episodes of care of patients who did not receive any form of intravenous chemotherapy. "At least one other IV chemo" replicates the base model on a subsample of episodes of care of patients who received intravenous chemotherapy other than 5-FU. "High charging doctors" replicates the base model on a subsample of providers who charged top-quartile consultation fees in the before period. "Low charging doctors" replicates the base model on a subsample of providers who charged bottom-quartile consultation fees in the before period. Results for high vs low charging doctors could not be estimated for use of chemotherapy medications. "Announcement date effects" sets D_t=1 if the episode of care commenced after November 30, 2014. The treatment effect for changes in the probability of supply of oral chemotherapy medication, capecitabine or its intravenous analogue, 5FU is reported as the average marginal effect from a probit model. For other outcomes, the treatment effect is reported as the coefficient estimate β_4. Standard errors clustered by cancer type in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6.2 Robustness checks

A key concern with our identification strategy is that changes over time in cancer-specific technologies may invalidate the underlying assumption in our difference-in-difference model, such that our baseline treatment and control groups lack comparability in outcome trends. To address these concerns, we present three robustness checks.

The first check implements an alternative control group – patients with haematological cancers, for whom oral chemotherapy treatment with capecitabine is ineffective. Summary data on these patients is provided in Appendix Table 1 and shows that the composition of this group was stable over time. This model includes services provided by haematologists in addition to oncologists. Table 5 presents the results on key outcomes from this model with the alternative control group. It also confirms the increased uptake of oral chemotherapy and decreased use of traditional intravenous treatment. Other results using this alternative control group showed point estimates with magnitudes in line with our baseline results and overlapping confidence intervals but suffered from large standard errors and were not significant.

Secondly, we present results from a placebo model, a test for spurious results. That is, we replicate our model using data from 2012 to 2016, with March 2014 denoting the before and after period for a placebo reform. The 24-month period before and after this time was not impacted by any policy shocks, and we should not find any significant results. The results in Table 4 indicate that, as expected, all estimated placebo effects were small in magnitude and not statistically significant.

Finally, we present results from a model restricting the sample to female patients only. The purpose of this check is to allay concerns that our main all-female control group of breast cancer patients may induce unobserved effects in outcomes due to difference in gender pairings between patient and provider. The results in Table 5 are again qualitatively very

similar to our baseline estimates, with overlapping confidence intervals and effects of similar magnitude and direction. Due to the smaller sample size, there was some loss in statistical precision. In summary, our baseline results were robust to a range of falsification checks. Overall, we found support for our empirical approach.

Table 5. Robustness checks

TREATMENT EFFECTS	Sample size	Probability of oral chemotherapy	Probability of traditional chemotherapy	Number of capecitabine scripts	Number of 5FU scripts	Price charged per infusion service	Number of infusion services	Price charged per consultation service	Number of consultations	Total price charged
Baseline	1,850	0.154**	-0.07***	0.207**	-0.028	0.021*	1.332**	0.002	0.667**	0.23***
		(0.073)	(0.025)	(0.093)	(0.135)	(0.011)	(0.610)	(0.010)	(0.294)	(0.047)
Haematological cancer control group	1,866	0.096**	-0.052**	0.173	-0.052	0.038	1.979	0.042	0.799	0.107
		(0.044)	(0.024)	(0.111)	(0.116)	(0.033)	(1.873)	(0.028)	(0.942)	(0.143)
Placebo model	1,732	0.009	0.022	-0.088	0.083	0.016*	-0.186	-0.012	-0.218	-0.062
		(0.026)	(0.026)	(0.055)	(0.098)	(0.009)	(0.374)	(0.017)	(0.194)	(0.074)
Female patients only	677	0.186**	-0.094**	0.220*	0.133	0.011	2.066	-0.005	1.134*	0.289*
		(0.086)	(0.04)	(0.112)	(0.164)	(0.014)	(1.346)	(0.014)	(0.633)	(0.158)

"Haematological cancer control group" compares the treatment group to an alternative control group of patients with haematological cancers, and includes services provided by both oncologists and haematologists. "Placebo model" replicates the base model for a placebo reform which is defined as occurring on March 1, 2014. "Female patients only" excludes male patients from the base model. The treatment effect for changes in the probability of supply of oral chemotherapy medication, capecitabine or its intravenous analogue, 5FU is reported as the average marginal effect from a probit model. For other outcomes, the treatment effect is reported as the coefficient estimate β_4. Standard errors clustered by cancer type in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

7. Discussion

In this study we have examined provider responses to the expansion of public subsidies for oral chemotherapy medications. We find that this new funding arrangement, which provided full reimbursement for the cost of the medication, expanded access to oral chemotherapy for cancer patients who were newly eligible for the subsidised treatment, with a 15.4 percentage point increase in the probability of receiving oral chemotherapy. We found a large decrease in the use of traditional intravenous chemotherapy.

This transition to oral chemotherapy is likely to have occurred due to changes in the treatment decisions or recommendations of the provider in conjunction with patient preferences for oral chemotherapy. We find that the provider response to the switch to oral chemotherapy was to increase infusion and consultation service volumes, which largely accounted for an average increase in the overall charge for an episode of care by 22.7 percent. However, these service volume and fee increases were concentrated amongst patients who were on chemotherapy regimens which required at least one intravenous treatment and therefore regular clinic visits. These more intensive, intravenous chemotherapy regimens are consistent with higher therapeutic needs.

Our results indicate that despite the lack of alignment between funding arrangements for the chemotherapy medications and services, there was little evidence that providers acted to compensate for reduced clinic income and activity by either slowing the transition to oral chemotherapy and/or increasing prices, even in a subsample of high-charging providers. We did not find strong evidence that observed increases in service volumes (e.g. more chemotherapy infusions) were driven by providers' self-interest. Although this result was contrary to our hypothesis of greater self-interested provider behaviour, existing studies provide an explanation. Although many studies have demonstrated strong supply responses to changes in financial incentives (Currie & MacLeod, 2008; Gruber et al., 1999; Yip, 1998),

Clemens and Gottlieb (2014) find that providers are more responsive to financial incentives in areas of more 'discretionary' healthcare (e.g. cataract surgery, elective caesarean birth), where changes in, for example, reimbursement rates can alter the supply response more dramatically. By comparison, in areas such as cancer care where treatment timing is less discretionary and the patient's marginal benefit of care is high, financial incentives play a lesser role. Our results provide further evidence of this differentiated supply response, and we extend the literature by showing that there was also no strong pricing response. From a policy perspective, understanding this differential response across areas of healthcare is essential to understanding the full consequences of policy changes.

Our results also suggest that the expansion of oral chemotherapy might free up in-clinic time to devote to patients still needing intravenous treatment, likely those receiving more intensive chemotherapy regimes as evidenced by the increase in infusion services. Evidence of increased attendances including case-conferencing for some patients on oral chemotherapy may represent a shift in activity towards out-of-clinic monitoring and coordination. This has positive welfare implications, as both patients suitable for and preferring at-home administration of oral chemotherapy, and patients needing more intensive in-clinic care, receive higher quality care in line with both therapeutic needs and preferences. From a policy perspective, the improved patient welfare, together with limited evidence of providers altering their supply response beyond what might benefit patients, would be regarded as a successful outcome.

Moreover, while we do not observe any provider cost data, it is possible that providers experienced improved efficiency, cost containment, and/or profitability. As Haywood et al. (2012) illustrate, in-clinic chemotherapy treatment features intensive use of staffing (particularly nursing) resources. The transition to at-home administration may represent an opportunity for more efficient or profitable use of clinic resources by either lowering staffing

needs, better focusing staff time on patients with greater need for in-clinic care, or deploying resources to more profitable activities.

There are other potential interpretations of these findings. First, providers may have become accustomed to more oral chemotherapy-based care through its existing use with breast and colorectal patients, and hence the new subsidies were not as disruptive to clinics as expected. In this case, providers would have already adapted to any potential adverse impacts associated with the transition to greater oral chemotherapy use. Second, it is possible that, due to our survey-based sample, providers may have compensated for loss of clinic activity and income by altering service and/or prices amongst patients outside our sample. We could not test these alternative explanations directly, however, because we could not observe each provider's total casemix of patients.

Other limitations to our study include a lack of cancer staging data to gauge the severity of disease and level of patient need. We also could not observe provider characteristics or facility-level identifiers, which limited our ability to explore heterogeneity across provider-specific traits or behavioural responses at the level of each treatment centre.

Nonetheless, this research demonstrates that understanding behavioural changes is central to supporting access to a wider range of medical technologies and is particularly instructive due to our fairly unique examination of fee-charging behaviour in this context. Future research in this area would benefit from population-based data with clinic-level identifiers to better identify the mechanisms at play.

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