NET WORK LISER

Discussion Paper Series

IZA DP No. 19027

October 2026

Menopause as a Health Shock

Nicole Black
Monash University

Maryam Naghsh-Nejad
University of Technology Sydney
and IZA@LISER

Serena Yu
University of Technology Sydney

The IZA Discussion Paper Series (ISSN: 2365-9793) ("Series") is the primary platform for disseminating research produced within the framework of the IZA@LISER Network, an unincorporated international network of labour economists coordinated by the Luxembourg Institute of Socio-Economic Research (LISER). The Series is operated by LISER, a Luxembourg public establishment (établissement public) registered with the Luxembourg Business Registers under number J57, with its registered office at 11, Porte des Sciences, 4366 Esch-sur-Alzette, Grand Duchy of Luxembourg.

Any opinions expressed in this Series are solely those of the author(s). LISER accepts no responsibility or liability for the content of the contributions published herein. LISER adheres to the European Code of Conduct for Research Integrity. Contributions published in this Series present preliminary work intended to foster academic debate. They may be revised, are not definitive, and should be cited accordingly. Copyright remains with the author(s) unless otherwise indicated.

Menopause as a Health Shock*

Abstract

Menopause is a near-universal biological transition for women, yet causal evidence on its health and healthcare consequences is scarce. Using longitudinal Australian survey data linked to administrative healthcare records, we leverage variation in the age of natural menopause to estimate the effect of menopause onset on non-hospital healthcare use, health outcomes and healthcare costs, using a stacked difference-in-differences event study design. We find a significant spike in the use of medical services in the year of and year after menopause onset, driven by increased general practitioner, specialist, investigative and therapeutic services. Examination of specialist service types reveals increases in care related to musculoskeletal, skin and cancer conditions sustained beyond the initial spike. These utilisation patterns are corroborated by increased diagnoses of arthritis and osteoporosis and greater self-reported limitations in physical functioning. We find no evidence of increases in care relating to psychiatry and neurology, respiratory health, endocrinology or gynaecology. In the year of and year after menopause onset, non-hospital medical costs increase on average by approximately 10 per cent per woman per year. Decomposing costs by payer reveals who bears the burden: government expenditure returns to baseline within two years of onset, while women's out-of-pocket costs rise before menopause and remain elevated three years afterwards. These findings demonstrate that menopause is a significant health shock, with financial implications for women and governments, underscoring the need for targeted health policy and service planning as our population ages.

JEL classification

I10, I12, I14, J16

Keywords

menopause, health care utilization, women's health, health shocks

Corresponding author

Maryam Naghsh-Nejad
Maryam.NaghshNejad@uts.edu.au

* The authors are grateful for comments and discussions received at the Australian Gender Economics Workshop, the Australasian Health Econometrics Workshop and the Australian Health Economics Society Conference, where the paper also received the Best Presentation Award. This research was completed using data collected through the 45 and Up Study (www.saxinstitute.org.au). The 45 and Up Study is managed by the Sax Institute in collaboration with major partner Cancer Council NSW and partner the NSW Ministry of Health. We thank the many thousands of people participating in the 45 and Up Study. The conduct of the 45 and Up Study was approved by the University of New South Wales Human Research Ethics Committee. We acknowledge the Sax Institute's Secure Unified Research Environment (SURE) for the provision of secure data access. Medicare claims data were provided by Services Australia. We thank the Centre for Health Record Linkage (CHeReL, www.cherel.org.au) for the provision of linked data. Ethics approval for this project was provided by the NSW Population and Health Services Research Ethics Committee (2020/ETH02894 / 2020.85 Sub Study Protocol 2021UMB0804) and the University of Technology Sydney Human Research Ethics Committee (ETH18-2507).

1. Introduction

Menopause represents a significant physiological transition marking the end of reproductive life for approximately half the global population, yet its health and economic impacts remain substantially underexamined. Defined as 12 consecutive months without a menstrual period, menopause for most women occurs around 50-51 years of age (InterLACE Study Team, 2019). Menopause is associated with an increased risk of a range of health conditions, including cardiovascular disease, osteoporosis, metabolic conditions, arthritis, dementia and cancer (Lobo and Gompel, 2022). It is also linked to negative symptoms which may commence before menopause itself, including hot flashes, depressive/anxious mood and sleep disturbances (Hickey et al., 2024). As our population ages, and more women enter menopause each year, it is critical to understand the impacts of menopause on health care use. It is not only relevant for women themselves but has wider economic implications for healthcare delivery and financing, labour market productivity and policies to support women. However, evidence on the causal impacts of menopause on health and health care use is scarce.

Using a stacked difference-in-differences (DiD) design applied to Australian survey data linked to administrative healthcare records, we produce evidence on the impacts of menopause onset on health and healthcare outcomes. The survey data come from the Sax Institute's 45 and Up Study, which asks a wide range of health questions, including age of menopause, to over 267,000 individuals aged 45 and over from Australia's most populous state, New South Wales. Self-reported menopause age has been shown to be a valid and reproducible measure (Colditz et al., 1987; Yap et al., 2022). The survey data are linked to administrative healthcare records on non-hospital medical services. These datasets combined allow us to measure health and healthcare use in relation to the timing of menopause. Our outcomes span the use of non-hospital medical services, the costs of that care (including how they are divided between government expenditure and women's out-of-pocket payments) and survey-based measures of diagnosed health conditions and functioning.

We use variation in the age of natural menopause (not medically induced) within the 'normal' range of 45 to 55 years to examine changes in healthcare outcomes of women in the years before and after menopause. We exclude women who experienced medically-induced menopause because these women may have a different health trajectory (Shuster et al., 2010). We further account for unobserved changes in health and healthcare patterns over time by differencing out changes in healthcare outcomes of a control group of same-aged men. Our use of a male control group differs from contemporary papers, which typically explore the impact of menopause using a control group of not-yet treated women. It is motivated by the challenge in constructing an age-matched control group of women who are uncontaminated by the large fluctuations in health that commonly occur in

the years preceding menopause. This perimenopausal stage is highly variable across women and can last up to 10 years (Avis et al., 2015; Li et al., 1996), making it difficult to assign an appropriate pre-menopause reference period, and ensure parallel trends. A further consideration is the need for not-yet treated women to experience menopause at a similar, but later age within the normal range of 45-55 years, while maintaining an adequate follow-up period that is uncontaminated by perimenopause.

A male control group has the advantage of not being subject to these considerations, and as a result, provides a much larger sample of controls with a longer follow-up period. Males are an appropriate control group under the same identifying assumption that is applied to not-yet treated females – that the health outcomes of both treated and control groups evolve in parallel in the absence of menopause. Contemporary studies suggest that this assumption does not always hold for some health or employment outcomes using not-yet treated women as controls (Juarez and Marquez-Padilla, 2025), and this may similarly be the case for certain outcomes when using males as the control group, particularly for female-specific outcomes. We test the parallel-trends assumption directly and report robustness checks using not-yet-treated women as controls.

We find that relative to age-matched males, women on average experience a significant jump in the average use of non-hospital medical services, by approximately one additional service per year (or about 7% relative to the pre-menopause mean) in the year of and year following menopause. The increase is broad-based, spanning general practitioner (GP) visits, specialist consultations and investigative and therapeutic services, and is temporary at the aggregate level, returning to baseline by the third year after onset. We estimate an almost identical response when we instead compare menopausal women with not-yet-treated women using a more restricted age-at-menopause sample and shorter follow-up period. Beneath the temporary aggregate spike, however, lie sustained increases in condition-specific care: visits to rheumatologists, dermatologists and cancer-related specialists remain elevated for at least five years after menopause, consistent with the onset or acceleration of chronic musculoskeletal, skin and cancer conditions that are known to be associated with the loss of estrogen. We find no robust increases in care relating to psychiatry and neurology, respiratory health, endocrinology or gynaecology.

The administrative records are corroborated by survey-based health outcomes. Menopause increases the likelihood of reporting an arthritis or osteoporosis diagnosis and increases self-reported limitations in physical functioning, including kneeling or bending, lifting shopping, climbing stairs and vigorous activity. Measures of emotional functioning and overall self-reported health are largely unchanged.

The healthcare costs closely mirror the utilisation dynamics: the total cost of non-hospital medical services rises by approximately A$100 per woman per year in the short-term (year of and year after menopause onset), equating to around 10% of the pre-menopause mean per year. Decomposing the costs reveals a distinction in cost trajectories between payers: the government-funded component of the increase is temporary, returning to baseline by the second year after onset, whereas women's out-of-pocket costs rise in the year before menopause and remain elevated through the third year after onset. In the short-term, women incur just under a quarter of the increase in total costs, well above the one-fifth patient-share in pre-menopause spending. In the medium-term (2-5 years after menopause onset), the increase in costs falls almost entirely on women, with no detectable increase in government expenses. Our heterogeneity analysis detects no difference in the health or healthcare utilisation response by women's socioeconomic background; however, we find that more advantaged women incur larger financial costs associated with their healthcare use.

Our study relates to three contemporaneous economic studies that examine the impact of menopause, predominantly on labour market outcomes, in the United States (Juarez and Marquez-Padilla, 2025), Norway (Abrahamsson et al., 2025) and in Norway and Sweden (Conti et al., 2026). These studies use women who reach menopause at a later age (not-yet treated) as a comparison group. Like our study, Juarez and Marquez-Padilla (2025) and Abrahamsson et al. (2025) use self-reported age at menopause from survey data, while Conti et al. (2026) use registry data and define the onset of menopause using the earliest record date of a menopause diagnosis. While a medical diagnosis is an objective measure, it focuses the study on women who seek medical care for menopause symptoms, which may depend on several factors such as the severity of symptoms and propensity to seek or access healthcare. Conti et al. (2026) report that their estimation sample comprises approximately one in three women of menopausal age. Self-reported age at menopause carries measurement error, but it is not conditioned on care-seeking behaviour or symptom severity, and has been shown to be a valid and reproducible measure (Colditz et al., 1987; Yap et al., 2022).

These three studies focus primarily on changes in economic outcomes including employment, income, government income support, and retirement behaviour. Conti et al. (2026) also examine healthcare outcomes in detail and find that in Norway and Sweden, for those who seek care and receive a menopause diagnosis, the likelihood of any use of GP and specialist doctor services rises in the year following diagnosis before returning to baseline. They also show that in Sweden the use of medications (menopausal hormone therapy, antidepressants and antihypertensives) rises at diagnosis and remains persistently elevated, which they interpret as evidence that symptoms outlast healthcare contacts. Abrahamsson et al. (2025) (also in Norway) do not find the same rise in the use of GPs, nor in hospital visits, highlighting potential differences between samples of women who do and do not

seek care for menopause symptoms. While Abrahamsson et al. (2025) find an increase in probability of diabetes diagnosis, Juarez and Marquez-Padilla (2025) do not. The lack of consistency in the current evidence on the health impacts of menopause suggests more rigorous evidence is warranted.

We contribute to the current evidence in several ways. First, we identify menopause from self-reported age rather than clinical diagnosis or reported symptoms, enabling an examination into the impacts of menopause across the population of women. This is important because the health consequences of menopause are not limited to women experiencing symptoms: menopause may also alter the risk of subsequent health conditions independently of reported symptoms (Lobo and Gompel, 2022). This distinguishes our estimates from the medical literature documenting associations between menopausal symptoms and healthcare use (DePree et al., 2023; Guthrie et al., 2003; Sharman Moser et al., 2020; Williams et al., 2007).

Second, we decompose the healthcare response by service type and by medical specialty using administrative records, and we use self-reported conditions and physical limitations from linked survey data to support the interpretation of the healthcare utilisation patterns. We additionally use linked cancer screening registry data to investigate whether increases in oncology specialist care following menopause could be driven by an increase in the detection of cancer, rather than incidence of cancer.

Third, and most distinctively, we observe both the government-funded component and the patient out-of-pocket cost attached to every service. This allows us to ask not only how large the additional cost of menopause-related care is, but how it is shared between government and women themselves. With a combination of public healthcare financing and patient cost-sharing common across many health systems, our findings are likely to be relevant to many settings beyond Australia. We further explore how the healthcare costs differ by the socioeconomic background of women, which is important for informing the degree of inequality in who bears the cost across women.

Our paper also contributes to the economic literature on health shocks. This literature has focused predominantly on acute or relatively rare events, such as cancer diagnoses and hospitalisations (Dobkin et al., 2018; Fiebig et al., 2021; García-Gómez et al., 2013; Jones et al., 2020). Menopause presents a different type of health shock – one that is near universal among women. Although women know that menopause will occur, its precise timing is uncertain and its health impacts variable and unpredictable. These features make it important to investigate and quantify how women are impacted so that women can be better prepared for both the health and the financial consequences of menopause, and to inform policies that can support equitable access to healthcare.

2. Background

2.1 Menopause

Menopause refers to the permanent loss of ovarian function, and the related production of the hormone estrogen. The clinical threshold for menopause occurs when 12 months has passed since the last menstrual period. The menopause transition, known as 'perimenopause', is characterised as the shift from reproductive to post-reproductive life and occurs over several years. Perimenopause is characterised by hormonal fluctuations which precipitate a range of symptoms which also vary in duration and severity and can extend beyond the final menstrual period. These include vasomotor symptoms (hot flashes, sweating, and chills), urogenital symptoms (vaginal dryness, recurrent urinary tract infections, pain during sex), sleep disruption, headaches and migraine, depression and anxiety, and cognitive changes such as a decline in memory and concentration (Monteleone et al., 2018; Santoro et al., 2021). The personal impact of these symptoms varies greatly. For some women, menopausal symptoms are likely to be highly distressing and have profound impacts on daily life, while others will experience no negative implications. As an indication, in a recent Australian survey of women aged 45-64, 41% of respondents reported that bothersome menopause symptoms had made daily activities difficult, while 43% reported no impact (Jean Hailes for Women's Health, 2024).

There is no single definitive test for perimenopause – while blood tests can determine certain hormone levels, these readings are misleading due to the fluctuations in hormones during perimenopause. Consequently, perimenopause is diagnosed clinically, based on symptoms and changes in menstrual patterns, and by exclusion of other conditions. Most women experience menopause between the ages of 45 and 55, with less than 10% of women experiencing menopause early (ages 40 to 44) or prematurely (before age 40) (Mishra et al., 2019).

The transition to post-menopausal life also appears related to changes in the risk of chronic health conditions, irrespective of reported symptoms (Lobo and Gompel, 2022). For example, menopause is linked to: declines in bone health, which increase the risk of osteoporosis and fractures; weight and metabolic changes, which raise the risk of cardiovascular disease and diabetes; and, higher cholesterol and blood pressure levels, which raise the risk of adverse cardiovascular events (Monteleone et al., 2018; Santoro et al., 2021).

2.2 The Australian setting

Healthcare in Australia is characterised by a mix of public and private financing arrangements and provision. The Australian Government supports service provision through the Medicare program, which provides free or subsidised access to healthcare for all Australians. An important feature of the financing architecture of the Medicare system is that for each non-hospital medical service, Medicare

pays a nationally consistent rebate for each service, while physicians are free to set their own fees. This fee-setting ability can lead to considerable variation in out-of-pocket costs paid by patients, even when the same service is consumed. A physician can choose to accept the Medicare rebate as full payment, charging nothing to the patient at the point of care – known as 'bulk billing'. Otherwise, the patient pays the gap between the charged fee and the rebate as an out-of-pocket cost. Bulk-billing is far more common for GP consultations than for specialist consultations, and more common for low-income patients.

As a result, how any increase in healthcare use divides into government expenditure and patients' out-of-pocket costs depends not only on the mix of services used but also factors such as the billing practices of the physician. This ambiguity in who pays for healthcare motivates our decomposition of cost impacts by financing source in Section 6.

Women seeking treatment for menopause symptoms are likely to present first at the GP of their choice, who may recommend treatment (e.g. in the form of medications including hormone replacement therapy) or referral to further specialist consultation. However, it is important to recognise that many clinicians in Australia have received inadequate training on assessing menopause symptoms (Commonwealth of Australia, 2024), and both the woman and the clinician may not associate the prevailing symptoms (e.g. joint pain, brain fog and fatigue) with menopause. As in many high-income countries, the Australian government has recently made menopause a health policy priority in response to government inquiries, which have revealed a critical need for greater research evidence, consumer and clinician education/training, and funding for accessible, best-practice healthcare services for menopause.

3. Data

3.1 The 45 and Up Study and data linkage

We use data from the Sax Institute's 45 and Up Study, a large cohort study based in the population of the state of New South Wales (NSW), Australia, whose methods are described in detail in the Cohort Profile Update (Bleicher et al., 2023; see also 45 and Up Study Collaborators, 2008). Prospective participants were randomly sampled from the Services Australia Medicare enrolment database, which provides near complete coverage of the population; people aged 80 years and over and residents of rural and remote areas were oversampled. A total of 267,357 participants – including 143,232 women – joined the Study between 2005 and 2009 by completing a baseline questionnaire and giving signed consent for follow-up and linkage of their information to health and other databases. About 19% of those invited participated, and participants represent around 11% of the NSW population aged 45

years and over. The Study was not designed to be representative of the general population; however, exposure–outcome relationships estimated in the cohort have been shown to be consistent with those from population surveys with higher response rates (Bleicher et al., 2023; Mealing et al., 2010). Two follow-up questionnaires were administered in 2012–2015 (Wave 2) and 2018–2020 (Wave 3). The survey collected detailed data on patient demographics, socioeconomic status, health status, and health behaviours, including menopause status and age at menopause. We do not observe data on menopause symptoms. This means that although we can examine the average effect of menopause on healthcare use, as well as how this may vary across demographic subgroups, we are unable to explore the role of symptoms.

The 45 and Up Study data were linked by the NSW Centre for Health Record Linkage (CHeReL) to NSW Cancer Registry and BreastScreen NSW records, using a probabilistic procedure in which records with an uncertain probability of being a true match are reviewed manually. Medicare claims data were provided by Services Australia; linkage of the 45 and Up Study cohort data to the Medicare claims data is facilitated by the Sax Institute using a unique identifier assigned at recruitment and deterministic matching. All participants consented to linkage with administrative data at enrolment, and CHeReL maintains a Master Linkage Key for the cohort. Coverage of the claims data is close to complete with Medicare records held for over 99% of active participants (those who consented and have not withdrawn from the study) with coverage of the full cohort from September 2005 (Sax Institute, 2021a). CHeReL reports a false-positive linkage rate of no more than 0.5%, or five in every thousand records (www.cherel.org.au).

3.2 Menopause measure

In each survey wave, women are asked: '*Have you been through menopause*?' Response options include: '*No*'; '*Not sure'; 'My periods have become irregular*'; and, '*Yes'*. For those that answered '*Yes'*, they are then asked '*How old were you when you went through menopause*?' and asked to respond with their age in years (question wording and response categories are documented in the 45 and Up Study questionnaires and data dictionaries; Sax Institute, 2013, 2020, 2021b). This self-reported age-at-menopause denotes the age that women were 12 months after their last period (the definition of menopause). As with any self-reported measure, reported age at menopause may be a noisy measure of the timing of menopause, which may lead to imprecision in our estimates. However, it bears noting that two studies have found self-reported menopause age to be both broadly valid (70% to 82% of women report natural menopause age to within one year of the age drawn from medical records), and reproducible (most women report the same menopause age across repeated surveys) (Colditz et al., 1987; den Tonkelaar, 1997).

We take a woman's age at menopause from the first wave at which she reports having been through menopause. We convert reported age at menopause into a calendar year of onset using date of birth, and define event time as the difference between the calendar year of a service record and the year of onset. Because we require onset from 2006, the first year of complete Medicare claims data, and because the survey waves were fielded in 2005–09, 2012–15 and 2018–20, women in the estimation sample report a transition that occurred within a few years of a survey contact, reducing the scope for recall error. Women whose menopause preceded the study period, for whom recall intervals would be long, are excluded by that same restriction.

3.3 Healthcare utilisation outcomes

Healthcare utilisation is measured using Medicare claims data for services listed on the Medicare Benefits Schedule (MBS). These data capture all subsidised medical services provided outside of hospital settings, including GP consultations, specialist visits, diagnostic tests and imaging, therapeutic services, and selected allied health services. For brevity, we refer to these services collectively as medical services. For each individual, we construct measures of annual utilisation based on all medical services claimed during the observation period. Utilisation outcomes include the total number of services, counts by broad service category (GP consultations, specialist consultations, investigative services and therapeutic services) and counts of specialist consultations by specialty. We additionally draw on linked NSW Cancer Registry and BreastScreen NSW records for supplementary analyses.

3.4 Healthcare costs

For every Medicare claim we observe both the rebate paid by the government and the fee charged by the provider, which allows us to construct comprehensive measures of the cost of the non-hospital medical services and who pays for them. Our cost outcomes are: (i) government expenditure, the sum of Medicare rebates paid for an individual's services in a year; (ii) patient out-of-pocket costs (zero for bulk-billed services); and (iii) total costs, the sum of the two. Costs are aggregated annually, overall and by service category, and are expressed in real Australian dollars, indexed to 2022 prices.

3.5 Survey health outcomes

Health outcomes are measured using self-reported information from the 45 and Up Study baseline and follow-up surveys. Respondents report whether they have ever been diagnosed with a range of conditions by a medical professional, including cardiovascular disease, diabetes, arthritis, osteoporosis, cancer, or depression, and other chronic illnesses relevant to midlife health. Other health measures relate to both physical and emotional health function, quality of life, and overall self-assessed health (item wording and response categories are documented in the 45 and Up Study

questionnaires and data dictionaries; Sax Institute, 2013, 2020, 2021b). These survey-based outcomes complement the administrative measures of healthcare utilisation by capturing diagnoses and functional limitations that are not directly observable in claims data and do not rely on healthcare seeking behaviour. Unlike the administrative data, survey outcomes are observed only in the two to three waves in which each respondent participated.

3.6 Identifying variation in menopause onset

Across three waves of the survey, we identify 20,256 women whose reported menopause fell within our study period (between 2006 and 2020). We exclude women who experienced medical menopause,[1] as their health and healthcare trajectories likely differ substantially from those experiencing natural menopause. We further exclude women who experienced menopause before age 45 or after age 55 as both early and later onset menopause can lead to different health trajectories compared with menopause onset within the normal age range. The distribution of menopause ages is shown in Appendix Figure A1 and shows that in our sample the most common age of menopause is 52 years. Our main sample comprises 10,743 women and 60,753 men (109,370 and 2,826,982 individual-year observations on women and men, respectively).

The scientific consensus regards menopause age as a complex genetic trait, with evidence from clinical data on twin sisters estimating the variation in menopause age attributable to genetic factors to be 63% in a UK sample (Snieder et al., 1998) and 71% in a Dutch sample (de Bruin et al., 2001). Studies have documented correlations between socioeconomic and reproductive characteristics and the timing of menopause (Gold, 2011), however, their effects are regarded as small and inconclusive (van Noord et al., 1997; Voorhuis et al., 2010). To explore this in our setting, we implement a linear regression model to measure the correlation between a range of baseline characteristics (measured in Wave 1, prior to menopause) and age of menopause in our sample of women. The results in Appendix Figure A2 show that these characteristics explain only around 1% of the variation in age at menopause, although many returned statistically significant results. Of these, smoking, living in a major city, or not having any children were associated with earlier age of menopause. Conversely, having private health insurance, a degree or higher qualification, or living in an area of low socioeconomic disadvantage were associated with a later age at menopause. In all cases however, the average effect was found to be small – a shift of between 1.4 and 2.9 months in the age at menopause.

While the onset of menopause is not completely random, its precise timing cannot be strategically manipulated. Following the same argument from emerging studies on the menopause "penalty"

[1] This includes women who had hysterectomy, and/or double-ovary removal, surgery, as well as cancer patients who likely received either radiotherapy or chemotherapy treatment.

(Abrahamsson et al., 2025; Juarez and Marquez-Padilla, 2025) and from the more established child "penalty" literatures (e.g. Andresen and Nix, 2022; Kleven et al., 2019), the onset of menopause induces changes in women's outcomes that are orthogonal to other unobserved determinants of the outcomes. Therefore, its onset leads to plausibly exogenous changes in healthcare outcomes.

In Section 6.2, we explore heterogeneity in our main results, and demonstrate that the results are similar by age at menopause group, and socioeconomic background, suggesting that in our study context, neither age of menopause (within the normal range) nor its correlates influence the impact of menopause on healthcare use.

4. Empirical approach

We use a difference-in-differences approach to estimate the impact of menopause on health and healthcare use. We measure within-individual changes in women's health outcomes, before and after menopause onset, and difference-out the changes experienced by an age-matched control group. A challenge is ensuring an appropriate control group. The recent literature on two way fixed effects models with staggered roll-out and heterogeneous treatment effects (De Chaisemartin and d'Haultfoeuille, 2020) highlights the problem of using already-treated units as a control group (i.e., the "forbidden comparison"). A solution adopted by recent studies (Abrahamsson et al., 2025; Conti et al., 2026; Juarez and Marquez-Padilla, 2025), is to use not-yet treated women as the control group in a difference-in-difference (DiD) setup (Callaway and Sant'Anna, 2021; Cengiz et al., 2019; Sun and Abraham, 2021). However, this approach is only valid if the not-yet treated women (who experience menopause at a later age) are comparable to earlier treated women, and importantly, follow similar health trajectories. Ageing, which is intertwined with menopause, leads to an increased risk of various health problems, and suggests that a woman aged 45 at menopause onset would have a different health trajectory to a woman whose menopause age is much later at age 55. The recent studies address this concern by creating a control group of not-yet menopausal women whose menopause age is similar (e.g. within five years).

An alternative approach, which we adopt, is to use age-matched men as our main control group. The main advantage of using males is that they experience a much more gradual decline in hormones over a longer period of time (Gray et al., 1991), allowing us to avoid the issue of having a control group that is potentially 'contaminated' by the significant fluctuations and steep decline in hormones that is experienced in the years just before menopause. While it is possible to allow for several years of perimenopause in a control group of not-yet treated women, the precise duration of perimenopause varies considerably – it can last from one to ten years (Avis et al., 2015; Li et al., 1996). Allowing

for perimenopause also restricts the range of possible menopause ages for both the treated and control groups. For example, if we were to examine the health outcomes at age 53 for a cohort of women who experienced menopause at age 50, and we assumed a perimenopausal period of three years, we would require the age-matched not-yet menopausal control group to be at least 56 at menopause, which is outside the 'normal' range of menopause. This limits the analysis to women who experienced menopause at earlier ages, and/or requires stronger assumptions about the duration of perimenopause.

The use of a male control group without these restrictions yields a significantly larger sample and subsequent statistical power, as well as a longer follow-up period. The main assumption with using males as a control group is the same as if any other control group were chosen – that their healthcare outcomes would have followed a similar trajectory to that of women in the absence of menopause. While we cannot directly test for this, we can test for parallel trends (Roth, 2022). We show that for most outcomes, men and women have similar pre-treatment trajectories.

As a robustness check, we implement a similar approach to recent papers, comparing menopausal women to age-matched, not-yet treated women who experienced menopause five years later. The results are based on more limited data and stronger assumptions, but show similarity in the results for key outcomes. We provide more detail on this approach in Appendix B.[2]

Within our main stacked DiD framework, we compare a treatment group of women who experience menopause at age *m* with a same-age counterfactual group of men. Due to the potential importance of age of menopause onset, we avoid pooling all menopause events in a standard event study. Rather, we follow Cengiz et al. (2019) and Deshpande and Li (2019) and construct menopause-age-specific sub-cohorts for women experiencing menopause at each age from 45 to 55, and stack these into a single dataset. We construct menopause-age-specific sub-panels as follows. For women experiencing menopause at age *m* (e.g. 50), the control group comprises men also aged *m*. Each sub-panel contains observations on these men and women from ages *m* – 5 to *m*+5. We estimate the following for each sub-panel:

$$Y_{iat}^{m} = \sum_{\substack{\tau=-5,\\ \tau\neq-3}}^{5} \alpha_{\tau m} I_{it}^{\tau m} I_{i}^{m} + \mu_i + \delta_t + \gamma_{am} + \varepsilon_{iatm} \quad (1)$$

[2] Essentially, we construct seven event-specific sub-cohorts of women experiencing menopause at ages 45,46, 47, 48, 49, 50 and 51 to allow adequate samples in both treatment and control groups (ensuring not-yet treated women experience menopause within the normal age range). To maximise the number of available cohorts under this approach, the years of observation are reduced and the reference period is set to $\tau = -1$, allowing two years of pre-treatment estimates.

Where Y_{iat}^{m} is the outcome for individual *i* at age *a* in calendar year *t,* in the sub-panel where the treated group experienced menopause at age $m \in [45,55]$ (and the control group comprises age-matched men). $I_{it}^{\tau m}$ are lead and lag indicator variables equal to 1 if the observation occurred τ years from age *m,* $\tau \in [-5,5]$. The reference period is set to $\tau = -3$ to account for a three-year period over which perimenopausal symptoms may emerge. In robustness checks we vary the reference period and find that our main results are unchanged. I_i^m is an indicator variable denoting the treatment group, equal to 1 for women, and zero for men. We include individual, age and year fixed effects, μ_i , γ_{am} and δ_t. Each woman appears in one sub-panel only, while we allow males to be controls in multiple panels across the study period. The coefficients of interest are $\alpha_{\tau m}$, representing the treatment effects τ years from menopause for women who experienced menopause at age *m*, relative to health outcomes at $\tau = -3$, which we depict using event-style plots. Standard errors are clustered at the individual level.

To summarise the dynamic estimates and maximise power for less frequent outcomes, we also estimate two average treatment effects: a short-term effect covering the year of and the year following menopause (τ = 0 to 1); and, a medium-term effect covering the second to fifth years after menopause (τ = 2 to 5). These pooled estimates compare each horizon with the pre-menopause years τ = −4 and −3.

In addition to estimating the overall medical service utilisation patterns, we measure the impacts of menopause on medical services by medical specialty and on self-reported conditions and functioning. As these breakdowns involve the testing of several hypotheses concurrently, we report Benjamini-Hochberg false-discovery-rate q-values alongside conventional p-values in the relevant appendix tables.

Appendix Table A1 Panel A shows that the baseline characteristics for the treatment group of women and the control group of age-matched males are similar, including with respect to educational attainment, socioeconomic disadvantage of residential area, remoteness location, having children, language spoken at home and private health insurance status. Also shown in Panel B are the baseline characteristics for the sample using the alternative control group of not-yet-treated women and more restricted group of treatment women (with respect to age at menopause), which indicates similarity in the two groups across a range of socio-demographic characteristics.

While balance on observable characteristics is encouraging, our key identifying assumption is that the healthcare trajectories of the control and treatment groups would have been similar in the absence of menopause. This assumption is no more important using males as the control group than it is when using future-treated females as the control. We examine whether the parallel trends assumption holds

across different outcomes. Using our male control group, the assumption holds for aggregate service use and costs, and for most disaggregated specialist service types. However, it is weaker for sex-specific care (gynaecology), and for cardiology, which reflects the divergence in male and female heart disease incidence rates in middle age. For those two outcomes we rely on the not-yet-treated female design, which removes the sex contrast at the cost of a shorter window and a smaller sample. We additionally show cancer-related specialist service outcomes using the not-yet treated female design as a robustness check given sex-differences in the most common types of cancer.

5. Results

5.1 Impact of menopause on medical services

In Figure 1 we present our main DiD estimates of the effect of menopause onset on non-hospital medical services. Panel A, based on our main specification with age-matched male controls, shows a significant spike in the total number of medical services in the year of, and the year following, menopause onset: women use approximately one additional service in each of these years, an increase of about 7% relative to the pre-menopause mean of 13.2 services per year ($p<0.01$). The increase is temporary at the aggregate level, declining from the second year post-menopause and returning to baseline by the third year. The corresponding regression estimates are presented in Appendix Table A2.

We see visual evidence of parallel trends – in the years preceding the reference year ($\tau = -3$), as well as in $\tau = -2$, we find that the estimates are close to zero and not statistically significant. This is corroborated by more formal tests, based on the Honest DiD approach by Rambachan and Roth (2023), which allows for possible pre-treatment divergence of trends, but bounded in magnitude based on evidence from the pre-treatment period (see Appendix Figure A3, Panel A).[3] We show in Appendix Figure A4 that our results are similar to our baseline specification when we change the reference year to $\tau = -5$, indicating that an extended period of pre-menopausal symptoms is unlikely to contaminate our main estimates.

Panel B of Figure 1 presents estimates for the same outcome using not-yet-treated females instead of males as controls. The pattern and magnitude of the response are strikingly similar, with an increase of just over one service in the year of and the year following onset (about 8% relative to the pre-

[3] We model a 'relative magnitude' parameter M with values between 0.2 and 1.2, where M=1 refers to a violation of parallel trends as large as the pre-treatment violation. Focusing on the year of 'peak' effects, we find that the effects remain positive across a wide range of plausible bounds: up to M ≈ 0.8 for the number of medical services, and up to M = 1 for the total cost of medical services.

menopause mean of 13.8 services per year). See Appendix Table A3 for the corresponding regression estimates. The similarity of estimates across the specifications using two different control groups gives us greater confidence in the use of male controls.

In Table 1 we disaggregate the total medical service use by service category, reporting average annual short-term (years 0–1) and medium-term (years 2–5) estimates. The short-term increase is broad-based: GP visits rise by 0.17 per year (4% of the pre-menopause mean), specialist consultations by 0.12 (13%), investigative services (which include diagnostic tests, imaging and investigative procedures) by 0.53 (8%), and therapeutic services (which include surgical procedures, anaesthetics and radiation therapy in non-hospital setting) by 0.14 (36%). The breadth of the short-term response suggests women require increasing levels of primary healthcare as well as more specialised care and treatment services. In the medium-term, only specialist consultations remain marginally elevated. The corresponding event study plots by service category are presented in Appendix Figure A5. These show that specialist service use remains elevated three years following menopause onset, before returning to baseline, suggesting a moderate but sustained need for treatment of more complex or serious health conditions.

5.2 Which health specialists drive the effect?

We next explore which health conditions are driving the increase in specialist care that we see in Table 1. We focus on specialists that correspond with key health conditions that are known to be associated with menopause, including: rheumatology (for inflammatory and autoimmune conditions including arthritis and osteoporosis); cardiology (heart and circulatory conditions, including coronary artery disease and high blood pressure); dermatology (skin, hair and nail conditions including eczema and hair loss); psychiatry and neurology (mental and nervous system conditions including depression, mood disorders, migraine, stroke, multiple sclerosis); endocrinology (metabolic and hormone-related conditions including diabetes and thyroid disorders) and gynaecology (female sexual health issues). For all specialist types except for gynaecology, we use our main control group of age-matched males, while for gynaecology, we use not-yet treated women as controls.

Figure 2 reports short-term and medium-term estimates for specialist consultations by specialty, with the underlying estimates reported in Appendix Table A4 and the corresponding event study plots in Appendix Figure A6. Three areas of care show robust and persistent increases. Visits to rheumatologists rise by 0.020 per year in the short-term and remain 0.022 per year higher in the medium-term (an increase of over 80% relative to the pre-menopause mean of 0.024 visits). Dermatologist visits rise by 0.030 per year in the short-term and 0.033 per year in the medium-term (about a 35% increase relative to the pre-menopause mean of 0.095 visits). Cancer-related specialist

visits rise by 0.034 per year in the short-term and remain elevated in the medium-term (more than double the pre-menopause mean) and we examine this result in more detail below. These three results are not artefacts of testing many specialties: each remains significant at $q<0.001$ in both horizons after adjusting for the false discovery rate across the sixteen tests in Appendix Table A4.

We find no evidence of an increase in consultations relating to psychiatry and neurology, respiratory and sleep health, or endocrinology, and no change in gynaecologist visits when menopausal women are compared with not-yet-treated female controls. Estimated cardiologist consultations decline relative to male controls; however, the event study reveals a declining pre-trend (see Appendix Figure A6, Panel D), which likely reflects known higher rates of cardiometabolic disease among men at these ages, leading to diverging trends (Kelly et al., 2025; Zhernakova et al., 2022), rather than an effect of menopause. Consistent with this interpretation, when we instead use not-yet-treated female controls (for whom no pre-trend divergence is evident) we find no evidence of change in cardiologist consultations following menopause (Appendix Figure A7, Panel A). The absence of a gynaecology response may be because for women experiencing non-medical menopause within a normal age range, many menopausal gynaecological symptoms can be managed by a GP or other specialists.

5.3 Cancer-related care

The increase in cancer-related care is large in relative terms and merits closer scrutiny. Visits to oncologists more than double relative to the pre-menopause mean and remain elevated throughout the five post-menopause years observed. The increase is corroborated when menopausal women are compared with not-yet-treated female controls, among whom oncologist visits rise by approximately 0.08 in the year after onset (Appendix Figure A7, Panel B), a comparison that rules out explanations based on differences between male and female cancer trajectories at these ages. While this may indicate an increase in cancer caused by menopause, an alternative explanation is that menopausal symptoms increase contact with the health system and thereby the detection of cancer. We can test the detection channel directly by examining whether menopause onset impacts cancer screening rates. Breast cancer is the most common type of cancer among women,[4] and free breast cancer screening is available for all women from age 45 years. Using linked breast cancer screening registry data and not-yet-treated female controls, we find that screening rates are stable prior to menopause and there is no evidence of any change in screening behaviour following menopause (Appendix Figure A8). This finding suggests that, at least for the most common type of cancer, the increase in cancer-related

[4] Linked cancer registry data indicates that in our sample, 393 women were diagnosed with cancer after menopause, of which 225 (57.3%) relate to breast cancer.

care is not an artefact of changes in organised screening. It does not close every detection channel: cancers may also be found incidentally during consultations prompted by menopausal symptoms, and our data cannot rule this out. As shown in Section 5.4, the share of women reporting a cancer diagnosis does not change significantly after menopause under either control group. However, because cancer remains uncommon at these ages, even the doubling of oncologist visits we observe would imply a change in the share of women ever diagnosed that is likely to be well under one percentage point, inside the confidence interval of the survey estimate.

A specific consideration arising for cancer-related outcomes is the treatment of women diagnosed with cancer before menopause. Cancer treatment (particularly chemotherapy and radiotherapy) can disrupt ovarian function and shift the timing of menopause, and cancer survivors are subject to ongoing surveillance whose healthcare trajectory differs systematically from that of any control group. As described in Section 3.6, it is for this reason that we exclude women with a pre-menopause cancer diagnosis from the estimation sample. However, this may introduce a mild selection issue and does not allow our estimates to generalise to cancer survivors. Notably, cancer is rare in our age range, with only 2% of women overall excluded due to a pre-menopause cancer diagnosis. In Appendix Figure A9, we show that our results for oncology specialist care are very similar when all prior cancer patients are retained.

5.4 Reported health outcomes

To further support the observed changes in healthcare use, we examine changes in both reported diagnosed health conditions and health functioning in the years before and after the menopause, using survey data from the 45 and Up Study. Note that unlike the healthcare use data, we do not observe each respondent annually, but only in 2-3 survey waves. We build the sub-cohorts as previously described in equation (1).

The results in Figure 3 (and corresponding estimates in Appendix Table A5) show statistically significant increases in the likelihood of ever having received a diagnosis of arthritis (1.5 percentage points) and osteoporosis (1.7 percentage points) in the medium-term, precisely the conditions implied by the sustained increase in rheumatology care documented in Section 5.2. We find no evidence of an increase in diagnoses of asthma, depression, high blood pressure or heart disease. The likelihood of reporting a diabetes diagnosis falls modestly in the medium-term (1.8 percentage points); we interpret this cautiously, noting mixed findings in the contemporary literature (Abrahamsson et al., 2025; Juarez and Marquez-Padilla, 2025). The increased diagnoses of arthritis and osteoporosis are consistent with reduced physical functioning, with menopausal women reporting both short- and medium-term increases in limitations in kneeling/bending, lifting shopping and vigorous activity, and

a medium-term increase in limitations in climbing stairs (see Appendix Table A5). The results for emotional functioning and overall self-reported health are generally close to zero and statistically insignificant.

Adjusting for the false discovery rate across the forty-two tests in Appendix Table A5 leaves the medium-term results intact: the effects on any physical limitation, vigorous activity, climbing stairs, kneeling or bending, osteoporosis and diabetes all survive at $q<0.01$, and lifting shopping survives at $q<0.05$ ($q=0.037$). The short-term functioning effects do not (only kneeling or bending survives at $q<0.05$, with $q=0.017$), nor does the medium-term increase in reported arthritis ($q=0.081$), which we therefore treat as suggestive rather than established. When we use not-yet-treated females as controls the estimates are similar but considerably less precise, and none are statistically distinguishable from zero (Appendix Table A6).

5.5 *Role of hormone replacement therapy*

Hormone replacement therapy (HRT) is typically prescribed to women to replace declining hormones (primarily estrogen) to relieve symptoms of menopause, such as hot flashes, night sweats, joint pain and sleep issues. By reducing symptoms, it may reduce the need for women to seek further medical care for such symptoms, potentially reducing visits to GP and specialist doctors. The use of HRT may also reduce the risk of certain chronic conditions, such as osteoporosis and fractures, which could also lead to reduced downstream healthcare services, including fewer diagnostic tests and procedures. HRT use is not random – women who use HRT may have had more severe menopausal symptoms, be more aware of the benefits of using HRT or have access to medical services that more readily prescribe HRT. Despite potential selection into HRT use, it is useful to explore whether the healthcare impacts of menopause differ by HRT use.

Appendix Table A7 reports pooled short- and medium-term estimates for the total number of non-hospital medical services from a specification that interacts the treatment-by-post indicator with an indicator for whether the woman self-reported ever having taken HRT. Because HRT is prescribed to women and not to men, this comparison uses the not-yet-treated female controls described in Appendix B. In our study sample, 16.8% of women were identified as ever being HRT users. In the short-term the response to menopause is similar in the two groups: women who never used HRT use about 1.2 additional services per year in the year of and the year after onset, and the differential for HRT users (-0.15 services, standard error 0.55) is small and imprecise. The two groups diverge in the medium-term. Among women who never used HRT, service use returns to baseline, whereas HRT users continue to use about 1.3 additional services per year (differential 1.41, standard error 0.65, $p=0.03$), an increase of similar size to the short-term response. The temporary aggregate response

documented in Section 5.1 therefore conceals a persistent increase concentrated among the roughly one in six women treated with HRT. Two mechanisms are consistent with this pattern and we cannot separate them. HRT itself generates ongoing contact with the health system, since prescriptions must be renewed and clinical guidance recommends regular review of treatment. At the same time, selection into HRT is likely to reflect more severe or persistent symptoms, so the persistence may partly reflect the underlying condition rather than its treatment.

6. The financial costs of increased medical services and who bears them

6.1 The financial costs of menopause-related medical services

In this section, we measure the financial costs associated with the increase in medical service use and how much the government and women themselves each contribute to these costs. Figure 4 presents event-study estimates using our main specification with male controls for the total cost of medical services (Panel A) and for its disaggregation into government expenditure and patient out-of-pocket costs (Panel B). Appendix Table A2 reports the underlying estimates. Total costs closely mirror the utilisation dynamics: they rise by approximately A$100 in the year of menopause and A$98 in the year following (around 10% of the pre-menopause mean of A$1,008 per year), remain elevated in the second year, and are indistinguishable from baseline thereafter. The close correspondence between the utilisation and cost dynamics is also evident under the alternative female-control design (see Appendix Table A3).

The financing decomposition reveals differences in cost patterns by government and patient contributions. The increase in the government-funded component (Figure 4, Panel B) is larger, but short-lived: expenditure per woman rises by about A$78 in the year of menopause and A$74 in the year following, and is no longer distinguishable from baseline from the second year. In contrast, the increase in women's out-of-pocket costs is more moderate but longer-lasting: costs per woman rise by approximately A$22 in the year of onset and remain significantly elevated to a similar level in each of the following three years, before becoming statistically indistinguishable from zero from the fourth year.

Table 2 summarises the annual short-term (years 0-1) and medium-term (years 2-5) estimates for all non-hospital services and the breakdown by broad category: GP visits, specialist visits, investigative services and therapeutic services. For all services combined, the pooled short-term estimate (A$83 per year, 8% of the pre-menopause mean) is somewhat smaller than the event-study coefficients for the year of and the year after onset reported above (approximately A$100 per year), because the pooled estimate is measured relative to the pre-menopause years τ=-4 and -3 together rather than τ=-

3 alone, and the τ=-4 coefficient is positive though imprecisely estimated (Appendix Table A2). The short-term increase in government expenditure is driven primarily by therapeutic and investigative services, with smaller contributions from GP and specialist services. The out-of-pocket increase is concentrated instead in GP and specialist consultations, and they are the only categories in which the out-of-pocket increase persists into the medium-term. Specialist consultations typically involve much higher out-of-pocket expenses than GP consultations. In the final column of Table 2, we see that out-of-pocket payments account for a greater share of the short-term specialist cost increase (54%) than the GP increase (39%). Appendix Figure A10 presents the corresponding event study plots for total costs by service category. Therapeutic services is the one category in which the parallel-trends assumption does not appear to hold. We are therefore cautious in applying a causal interpretation to the therapeutic cost estimate.

Table 3 shows the aggregate costs (and 95% confidence intervals) over the short-term (years 0 and 1) and medium-term (years 2-5) per average woman (columns 1-3) and per annual cohort of women experiencing menopause (columns 4-6). In the short-term, menopause raises the total costs per woman on average by A$199, of which A$46, or just under a quarter, is paid out of pocket, while the remainder (A$153) is funded by the government. In the medium-term, women pay an additional A$48 on average in out-of-pocket costs, while the government contribution and total costs are imprecisely estimated with confidence intervals including zero.

Although modest per woman, these effects imply a non-trivial aggregate footprint. In columns 4-6 we present back-of-the-envelope estimates of the national aggregate cost per year. We scale-up our estimates shown in columns 1-3 by multiplying them by 171,000, which is the approximate number of Australian women who were of the median age of menopause (52 years in our sample) in 2026.[5] Because the 45 and Up Study samples women from New South Wales, this scaling assumes that the per-woman estimated effects are generalisable to all Australian women of the same age. The 45 and Up Study was not designed to be representative of the population; however, our estimates are within-woman changes in response to menopause rather than population prevalence measures, and such exposure–outcome relationships have been shown to generalise well from the cohort (Mealing et al., 2010). Medicare is a national scheme with uniform government subsidies for the same service provided across the nation, which makes the assumption for government costs reasonable, but out-of-pocket costs can vary considerably by location and thus the resulting figures are best read as an illustrative extrapolation rather than a national accounting estimate. Applying our per-woman estimates to an annual cohort of women experiencing menopause indicates that menopause adds about

[5] Australian Bureau of Statistics population data indicate that in May 2026 there were approximately 857,000 Australian women aged 50–54, implying about 171,000 at age 52.

A$34 million (95% confidence interval: A$24 million to A$44 million) to the cost of non-hospital medical services over the two years around onset, of which A$7.9 million are borne privately by women themselves and A$26.1 million by the government through Medicare. In the medium-term, women pay a further A$8.3 million in out-of-pocket costs, while the government's contribution is not statistically distinguishable from zero.

6.2 *Who bears the increase? Heterogeneity in use and costs*

We next examine whether the impacts of menopause, and their financing, differ across women. Figure 5 plots the interaction terms, with 95% confidence intervals, from a specification which augments the stacked model with an interaction between the treatment-by-post indicator and each baseline characteristic in turn: degree-level education, reaching menopause at age 50 or earlier, living in a major city, holding private health insurance, being from a culturally and linguistically diverse (CALD) background, and living in the most versus least disadvantaged areas as measured using Socio-Economic Indexes for Areas (SEIFA) quintiles. The corresponding point estimates, standard errors and main treatment effects are reported in Appendix Table A8. Here we also report heterogeneity by earlier/later menopause age group, which is estimated within the female panel only, because men have no menopause age, and therefore has much wider confidence intervals than the estimates using the male control group.

The medical services utilisation response to menopause is remarkably uniform across education, insurance status, geography and area disadvantage, with none of the interaction terms statistically significant in the short- or medium-term (Figure 5, Panel A and Panel D). Having menopause onset at age 50 or earlier relative to later ages (within the normal age range) also appears to make little difference to the medical utilisation response to menopause (see Appendix Table A8), which provides further support that non-random timing of menopause is unlikely to drive our results.

While the lack of heterogeneity by socioeconomic factors may indicate that the health impacts of menopause impact advantaged and disadvantaged women similarly, an alternative interpretation is one of inequalities in access to needed care (Pulok et al., 2020). It is possible that the health response to menopause differs by socioeconomic status – women from more disadvantaged backgrounds may experience worse symptoms or health complications – but their access to care is at a similar level to more advantaged women. While our medical services records do not allow us to capture unmet need, we can use the self-reported health limitations data to explore whether more disadvantaged women suffer from worse health outcomes following menopause. Appendix Figure A11 presents four

summary measures of poor health (any physical limitation, any emotional limitation, poor self-rated health and poor quality of life) by socioeconomic characteristics in the short- and medium-term following menopause onset. Across all measures, we find no evidence that women from more disadvantaged backgrounds experience worse health following menopause. These results provide some indication that the health impacts and utilisation of health services following menopause are comparable across women, regardless of socioeconomic background.

Turning to the financing of the additional care, we find no evidence of heterogeneity in government expenditure (Figure 5, Panels C and F); the only significant interaction is a larger medium-term increase for women living in the most disadvantaged areas. Out-of-pocket costs behave very differently. In the short-term, greater out-of-pocket costs are borne by women with private health insurance and those living in more advantaged areas (Panel B). By the medium-term the socioeconomic gradient is larger and significant for every marker (Panel E). For example, out-of-pocket costs rise by an additional A$20 per year for women with a tertiary level education compared with non-tertiary-educated women, by A$30 for women in major cities relative to non-major cities and by A$55 more for women in the most advantaged areas compared to the most disadvantaged areas.[6]

The higher out-of-pocket costs incurred by more advantaged women is consistent with more bulk-billed (zero patient fee) services provided to low-income individuals (Pulok et al., 2020). The equity implications of this are ambiguous. While the additional out-of-pocket costs fall on the women best placed to absorb it, if the additional spending buys shorter waits, greater choice of practitioner or longer consultations, then the uniform service count conceals a gradient in the quality and timeliness of menopause care. Our data cannot settle this, and we regard it as an important question for future research. This pattern also contrasts with Conti et al. (2026), who find larger increases in GP use among college-educated women in Norway. We find no comparable gradient in the volume of services, but a pronounced one in what women pay: where fees are unregulated, advantaged women appear to obtain similar quantities of care at higher prices rather than more care.

7. Discussion and Conclusion

The study of the impact of menopause, a physiological transition which affects almost half the global population, is a nascent literature in the economics discipline, with only a handful of contemporaneous studies to our own. This is despite the clinical literature evolving to acknowledge that menopause is associated with elevated risks of chronic metabolic, musculoskeletal, urogenital,

[6] The SEIFA specification is estimated on women living in the most and least disadvantaged quintiles only.

and mental health conditions, together with potentially severe (peri)menopausal symptoms. The economics studies have focused on important economic outcomes such as employment, income and retirement behaviour, and found, on average, adverse economic effects (Abrahamsson et al., 2025; Conti et al., 2026; Juarez and Marquez-Padilla, 2025). We contribute to this emerging literature by undertaking a detailed study of the healthcare changes during these mid-life changes in health. Our findings demonstrate that menopause is a significant health shock – one that leads to temporary increases in the use of non-hospital medical services including GP visits, specialist consultations, investigative services and therapeutic services, together with a commensurate increase in the costs of this care. Beneath the temporary aggregate spike, however, lie sustained increases in condition-specific care: we find that visits to rheumatologists, dermatologists and cancer-related specialists remain elevated for at least five years after menopause.

The temporary spike in non-hospital medical services use that we find in the year of and year following menopause onset largely accords with Conti et al. (2026), who find a short-lived rise in primary and specialist care in Norway following a menopause diagnosis by an average of 5% and 31% per quarter respectively relative to the pre-diagnosis quarter over the eight-quarter follow-up period within the group of women who engaged with health care to receive diagnosis. This is a larger magnitude of effect compared to the 4% and 13% increase in GP and specialist consultations per year in our setting, which may be due to greater care-seeking among women with a menopause diagnosis, compared with the general population of women who experience menopause onset. In their setting, the increase in GP visits is largely concentrated in the quarter of diagnosis and specialist visits within the first few quarters following diagnosis, while in our setting, we see elevated GP visits in the year after menopause onset and elevated specialist visits sustained in the third year after menopause onset.

Although our large-scale data provide precise estimates of the increase in healthcare services for certain health conditions, we are unable to rule out the possibility that women may seek care for other menopause-related symptoms (e.g. hot flashes), which inadvertently leads to an increased detection of more serious or chronic health conditions. However, two findings lend support for the interpretation that menopause leads to an increase in these serious conditions, particularly cancer. First, we see a jump in healthcare use in the year of and year following menopause, with no divergence of trends in the preceding years. Since we do not find an increase in healthcare use during the peri-menopausal years, it is unlikely that the increase in any health conditions is due to incidental detection from seeking care for peri-menopausal symptoms. Second, our analysis using breast cancer screening registry data indicates that menopause does not lead to an increase in breast cancer screening, which we might expect to see if our cancer results were driven simply by an increase in screening behaviour.

Our cost results add an economic dimension that utilisation counts alone cannot capture and highlight differences over the post-menopause years in who predominantly finances the additional medical care under a universal public health insurance system with cost-sharing arrangements. We reveal that the government bears a temporary increase in non-hospital health services expenditure in the two years around onset (A$153 per woman), after which its expenditure is no longer distinguishable from baseline, while women bear a longer-lasting increase in out-of-pocket costs (A$46 per woman in year of and year after onset, and A$48 per woman in years 2-5). This private burden is concentrated among socioeconomically advantaged women despite a uniform increase in service use across groups. This is a pattern consistent with advantaged women paying more per service (less likely to be bulk-billed), however, the implications for the accessibility and quality of care for socioeconomically disadvantaged women remains an important area for future research.

The estimated average costs of menopause-related care are modest, but they conceal another important dimension on who bears the cost. The total average costs are spread across all women who reach menopause, including those for whom the transition generates little need for care. The costs borne by women requiring care, which may include women who experience more severe symptoms, will therefore be substantially higher than the average reported here. The split by HRT use in Section 5.5 offers some evidence in support of this, under the assumption that HRT is a marker for more severe menopausal symptoms. Among the roughly one in six women treated with HRT, service use remains elevated throughout the medium-term, whereas it returns to baseline for non-HRT users.

Our cost estimates are also economically meaningful when aggregated across the Australian population of women experiencing menopause each year. With approximately 171,000 women reaching the median age of menopause each year, the additional government expenditure on non-hospital medical services amounts to approximately $26 million in the two years around menopause onset (in A$2022). In those same two years, women pay about A$8 million, or just under a quarter of the aggregated short-term costs. In the 2-5 years after menopause onset, women accrue a further A$8 million in out-of-pocket expenses, the entire aggregated medium-term costs.

Our study, along with other emerging economics studies, has limitations documenting the prevalence, severity, and duration of (peri)menopausal symptoms, and necessarily estimate average effects across significant symptom heterogeneity. Investment in the collection of detailed symptoms data in large longitudinal studies linked to administrative records would enable the generation of more nuanced evidence. The regular collection of physical and diagnostic markers, such as bone density scans, skin exams and hormone tests would also allow future studies to more accurately measure the timing of certain physiological changes in relation to menopause. In addition, our cost estimates cover non-hospital medical services only; incorporating pharmaceutical, hospital and other allied healthcare

costs would likely raise the estimated costs of menopause-related care, so our figures are best read as a lower bound of total healthcare costs.

Our main findings highlight that compared to age-matched males and women who have not yet experienced menopause, post-menopausal women have greater health limitations and require more GP, specialist, investigative, and therapeutic services. This has important implications, not only for supporting women's access to appropriate care, but also with regards to gender equality in healthcare expenses. As we experience an unprecedented number of women transitioning to menopause each year, our results are highly pertinent to the financing and delivery of appropriate and accessible menopausal healthcare in Australia and globally.

References

45 and Up Study Collaborators, Banks E, Redman S, Jorm L, Armstrong B, Bauman A, et al. Cohort Profile: the 45 and Up Study. International Journal of Epidemiology 2008;37; 941-947.

Abrahamsson S, Barschkett M, Flatø M. 2025. Beyond Hot Flashes: The Career Cost of Menopause. IZA Discussion Papers; 2025.

Andresen ME, Nix E. What causes the child penalty? Evidence from adopting and same-sex couples. Journal of labor economics 2022;40; 971-1004.

Australian Bureau of Statistics. Labour Force, Australia: civilian population by age and sex. ABS: Canberra; 2026. Accessed via CEIC Data.

Avis NE, Crawford SL, Greendale G, Bromberger JT, Everson-Rose SA, Gold EB, Hess R, Joffe H, Kravitz HM, Tepper PG. Duration of menopausal vasomotor symptoms over the menopause transition. JAMA internal medicine 2015;175; 531-539.

Bleicher K, Summerhayes R, Baynes S, Swarbrick M, Navin Cristina T, Luc H, Dawson G, Cowle A, Dolja-Gore X, McNamara M. Cohort Profile Update: The 45 and Up Study. International Journal of Epidemiology 2023;52; e92-e101. https://doi.org/10.1093/ije/dyac104

Callaway B, Sant'Anna PH. Difference-in-differences with multiple time periods. Journal of econometrics 2021;225; 200-230.

Cengiz D, Dube A, Lindner A, Zipperer B. The effect of minimum wages on low-wage jobs. The Quarterly Journal of Economics 2019;134; 1405-1454.

Colditz GA, Stampfer MJ, Willett WC, Stason WB, Rosner B, Hennekens CH, Speizer FE. Reproducibility and validity of self-reported menopausal status in a prospective cohort study. American journal of epidemiology 1987;126; 319-325.

Commonwealth of Australia. 2024. Issues related to menopause and perimenopause. In: The Senate. Community Affairs References Committee. Commonwealth of Australia: Canberra; 2024.

Conti G, Ginja R, Persson P, Willage B. The Menopause "Penalty". CESifo Working Paper No. 11761 2026.

de Bruin JP, Bovenhuis H, van Noord PAH, Pearson PL, van Arendonk JAM, te Velde ER, Kuurman WW, Dorland M. The role of genetic factors in age at natural menopause. Human Reproduction 2001;16; 2014-2018.

De Chaisemartin C, d'Haultfoeuille X. Two-way fixed effects estimators with heterogeneous treatment effects. American economic review 2020;110; 2964-2996.

den Tonkelaar I. Validity and reproducibility of self-reported age at menopause in women participating in the DOM-project. Maturitas 1997;27; 117-123.

DePree B, Houghton K, Shiozawa A, Esterberg E, King DD, Kim J, Mancuso S. Treatment and resource utilization for menopausal symptoms in the United States: a retrospective review of real-world evidence from US electronic health records. Menopause 2023;30.

Deshpande M, Li Y. Who is screened out? Application costs and the targeting of disability programs. American Economic Journal: Economic Policy 2019;11; 213-248.

Dobkin C, Finkelstein A, Kluender R, Notowidigdo MJ. The economic consequences of hospital admissions. American Economic Review 2018;108; 308-352.

Fiebig DG, van Gool K, Hall J, Mu C. Health care use in response to health shocks: Does socio-economic status matter? Health economics 2021;30; 3032-3050.

García-Gómez P, Van Kippersluis H, O'Donnell O, Van Doorslaer E. Long-term and spillover effects of health shocks on employment and income. Journal of Human Resources 2013;48; 873-909.

Gold EB. The timing of the age at which natural menopause occurs. Obstet Gynecol Clin North Am 2011;38; 425-440.

Gray A, Feldman HA, Mckinlay JB, Longcope C. Age, disease, and changing sex hormone levels in middle-aged men: results of the Massachusetts Male Aging Study. The Journal of Clinical Endocrinology & Metabolism 1991;73; 1016-1025.

Guthrie JR, Dennerstein L, Taffe JR, Donnelly V. Health care-seeking for menopausal problems. Climacteric 2003;6; 112-117.

Hickey M, LaCroix AZ, Doust J, Mishra GD, Sivakami M, Garlick D, Hunter MS. An empowerment model for managing menopause. The Lancet 2024;403; 947-957.
InterLACE Study Team. Variations in reproductive events across life: a pooled analysis of data from 505 147 women across 10 countries. Human Reproduction 2019;34; 881-893.
Jean Hailes for Women's Health. 2024. The impact of symptoms attributed to menopause by Australian women. Jean Hailes for Women's Health: Melbourne, Victoria; 2024.
Jones AM, Rice N, Zantomio F. Acute health shocks and labour market outcomes: evidence from the post crash era. Economics & Human Biology 2020;36; 100811.
Juarez L, Marquez-Padilla F. Midlife Crisis: The Labor and Health Impacts of the Menopause Transition. Available at SSRN 5264120 2025.
Kelly RK, Harris K, Muntner P, Woodward M. Variations in sex differences in major cardiometabolic risk factors by age and menopause status: results from the UK Biobank. Open Heart 2025;12; e003182.
Kleven H, Landais C, Søgaard JE. Children and gender inequality: Evidence from Denmark. American Economic Journal: Applied Economics 2019;11; 181-209.
Li S, Lanuza D, Gulanick M, Penckofer S, Holm K. Perimenopause: the transition into menopause. Health Care for Women International 1996;17; 293-306.
Lobo RA, Gompel A. Management of menopause: a view towards prevention. The Lancet Diabetes & Endocrinology 2022;10; 457-470.
Mealing NM, Banks E, Jorm LR, Steel DG, Clements MS, Rogers KD. Investigation of relative risk estimates from studies of the same population with contrasting response rates and designs. BMC Medical Research Methodology 2010;10; 26.
Mishra GD, Chung H-F, Cano A, Chedraui P, Goulis DG, Lopes P, Mueck A, Rees M, Senturk LM, Simoncini T, Stevenson JC, Stute P, Tuomikoski P, Lambrinoudaki I. EMAS position statement: Predictors of premature and early natural menopause. Maturitas 2019;123; 82-88.
Monteleone P, Mascagni G, Giannini A, Genazzani AR, Simoncini T. Symptoms of menopause -- global prevalence, physiology and implications. Nature Reviews. Endocrinology 2018;14; 199-215.
Pulok M, van Gool K, Hall J. Inequity in physician visits: the case of the unregulated fee market in Australia. Social Science & Medicine 2020;255; 113004.
Rambachan A, Roth J. A More Credible Approach to Parallel Trends. The Review of Economic Studies 2023;90; 2555-2591.
Roth J. Pretest with caution: Event-study estimates after testing for parallel trends. American Economic Review: Insights 2022;4; 305-322.
Santoro N, Roeca C, Peters BA, Neal-Perry G. The Menopause Transition: Signs, Symptoms, and Management Options. The Journal of Clinical Endocrinology & Metabolism 2021;106; 1-15.
Sax Institute. 2013. 45 and Up Study Baseline Data Dictionary. Sax Institute: Sydney; 2013. https://www.saxinstitute.org.au/wp-content/uploads/Data-Dictionary-June-2013.pdf
Sax Institute. 2020. The 45 and Up Study Second Follow-Up (Wave 3) Data Dictionary. Sax Institute: Sydney; 2020. https://www.saxinstitute.org.au/wp-content/uploads/Second-Follow-up-Wave-3-Data-Dictionary.pdf
Sax Institute. 2021a. Technical Note: Linked MBS and PBS Data (Version December 2021). Sax Institute: Sydney; 2021. https://www.saxinstitute.org.au/wp-content/uploads/45-and-Up-Study-Technical-Note-Linked-MBS-and-PBS-Data.pdf
Sax Institute. 2021b. The 45 and Up Study Wave 2 Data Dictionary: First Follow-Up, 2012–2015. Sax Institute: Sydney; 2021. https://www.saxinstitute.org.au/wp-content/uploads/W2-data-dictionary-May2021.pdf
Sharman Moser S, Chodick G, Bar-On S, Shalev V. Healthcare Utilization and Prevalence of Symptoms in Women with Menopause: A Real-World Analysis. Int J Womens Health 2020;12; 445-454.
Shuster LT, Rhodes DJ, Gostout BS, Grossardt BR, Rocca WA. Premature menopause or early menopause: Long-term health consequences. Maturitas 2010;65; 161-166.

Snieder H, MacGregor AJ, Spector TD. Genes Control the Cessation of a Woman's Reproductive Life: A Twin Study of Hysterectomy and Age at Menopause. The Journal of Clinical Endocrinology & Metabolism 1998;83; 1875-1880.

Sun L, Abraham S. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. Journal of econometrics 2021;225; 175-199.

van Noord PAH, Dubas JS, Dorland M, Boersma H, Velde Et. Age at natural menopause in a population-based screening cohort: the role of menarche, fecundity, and lifestyle factors. Fertility and Sterility 1997;68; 95-102.

Voorhuis M, Onland-Moret NC, van der Schouw YT, Fauser BCJM, Broekmans FJ. Human studies on genetics of the age at natural menopause: a systematic review. Human Reproduction Update 2010;16; 364-377.

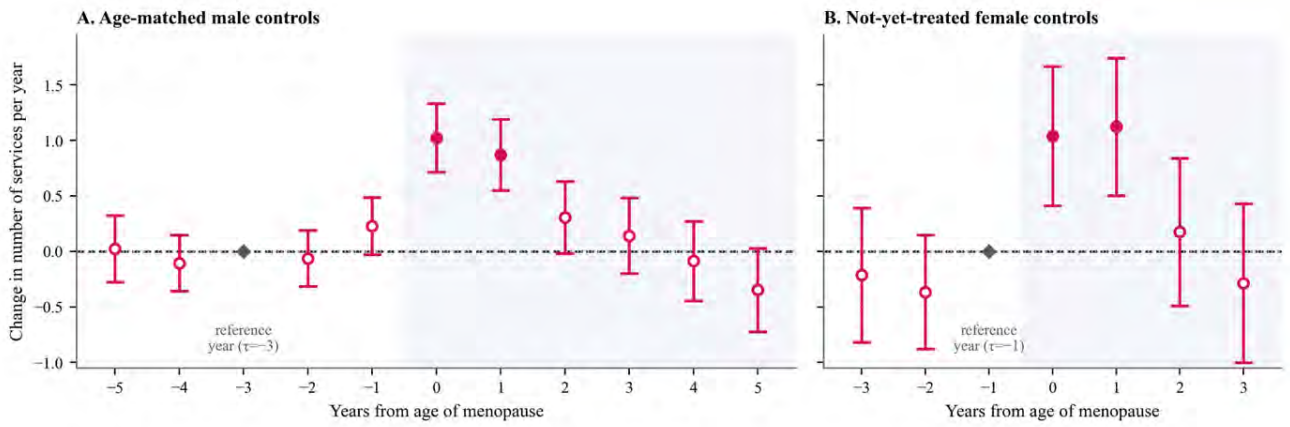
Williams RE, Kalilani L, DiBenedetti DB, Zhou X, Fehnel SE, Clark RV. Healthcare seeking and treatment for menopausal symptoms in the United States. Maturitas 2007;58; 348-358.

Yap S, Vassallo A, Goldsbury DE, Salagame U, Velentzis L, Banks E, O'Connell DL, Canfell K, Steinberg J. Accurate categorisation of menopausal status for research studies: a step-by-step guide and detailed algorithm considering age, self-reported menopause and factors potentially masking the occurrence of menopause. BMC Research Notes 2022;15; 88.

Zhernakova DV, Sinha T, Andreu-Sánchez S, Prins JR, Kurilshikov A, Balder J-W, Sanna S, Franke L, Kuivenhoven JA, Zhernakova A, Fu J, Lifelines Cohort S. Age-dependent sex differences in cardiometabolic risk factors. Nature Cardiovascular Research 2022;1; 844-854.

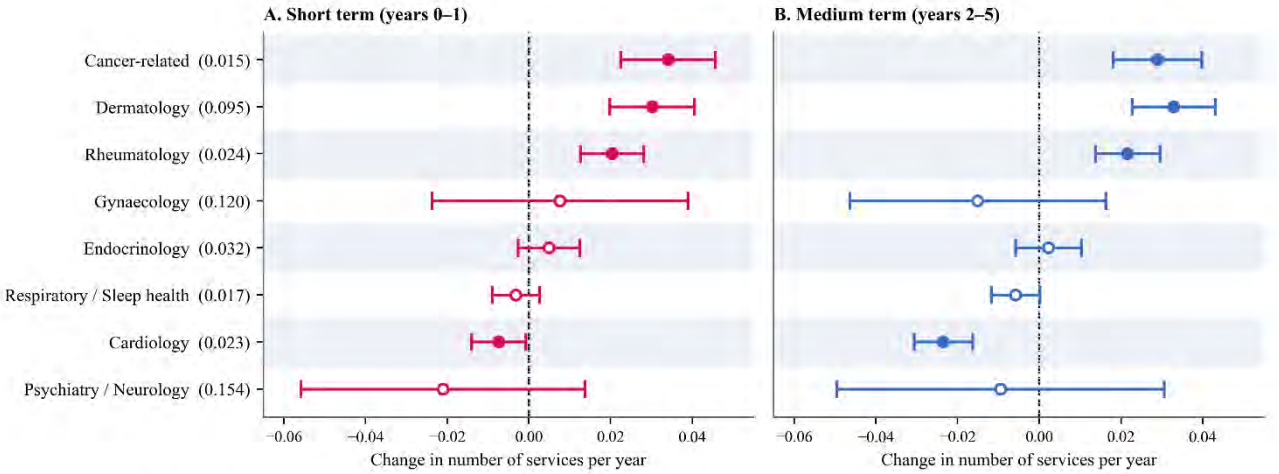
Figures

Figure 1. Changes in total number of non-hospital medical services used around menopause



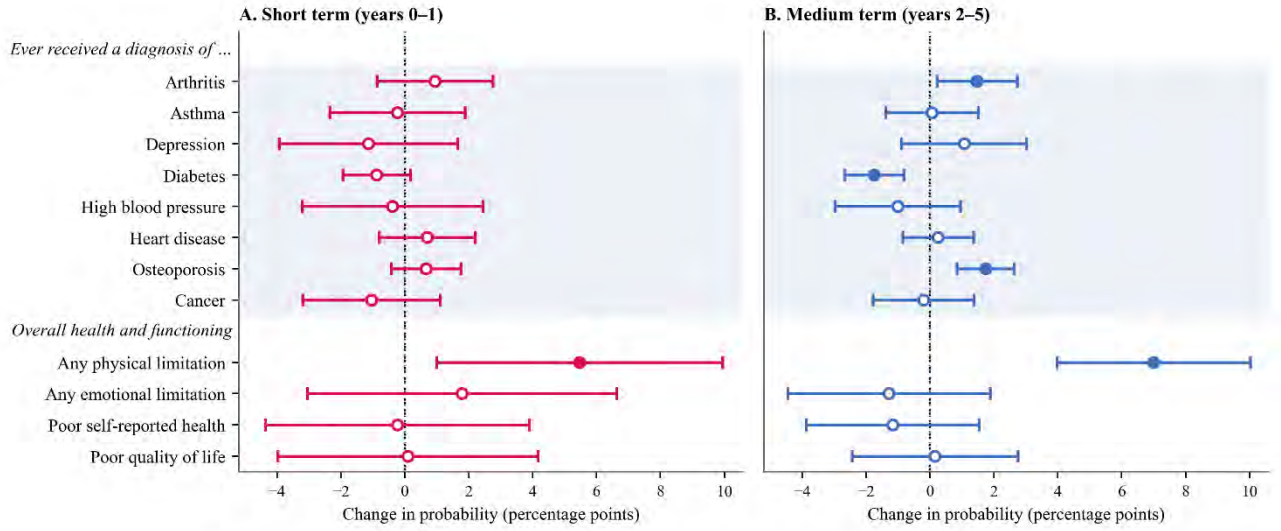
Notes: Results from a stacked difference-in-difference model. Panel A: Equation (1), using age-matched males as a control group and τ=-3 as the reference year. Panel B: alternative control group of not-yet-treated women (see Appendix B for details); both panels share a common vertical scale. Bars are 95% confidence intervals; filled markers denote estimates whose interval excludes zero.

Figure 2. Changes in specialist services used in the short- and medium-term by specialty



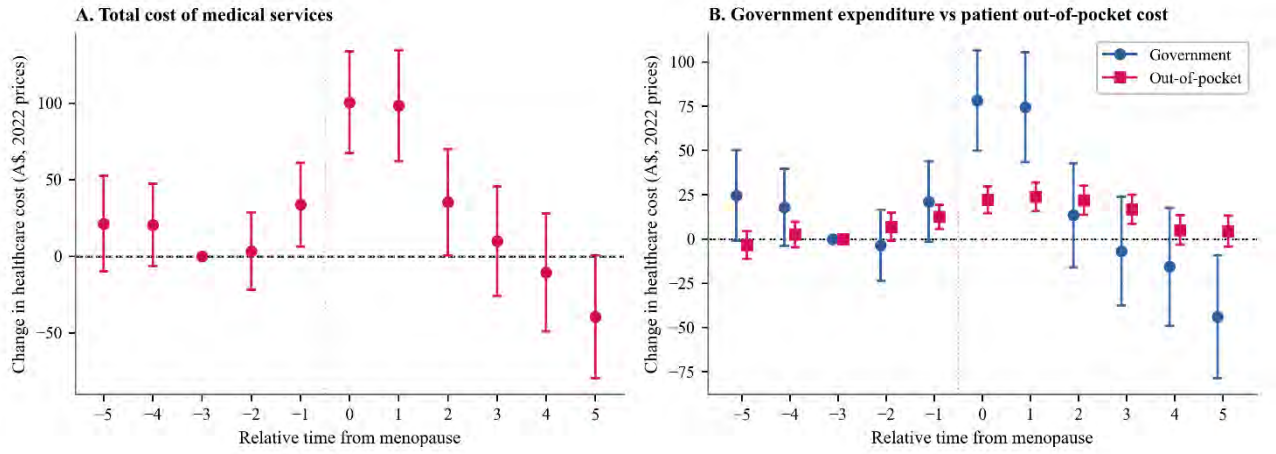
Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and the pre-menopause years τ=-4 and -3 as the reference period, with 95% confidence intervals. Panel A reports the average annual effect over years 0–1 and Panel B over years 2–5. Specialties are ordered by the size of the short-term effect; the pre-menopause mean number of services per year (averaged over τ=-5, -4 and -3) is shown in parentheses beside each label. Filled markers denote estimates whose confidence interval excludes zero. Gynaecology is estimated using an alternative control group of not-yet-treated women (Appendix B). The underlying estimates are reported in Appendix Table A4 and the corresponding event studies in Appendix Figure A6.

Figure 3. Changes in reported health outcomes in the short- and medium-term



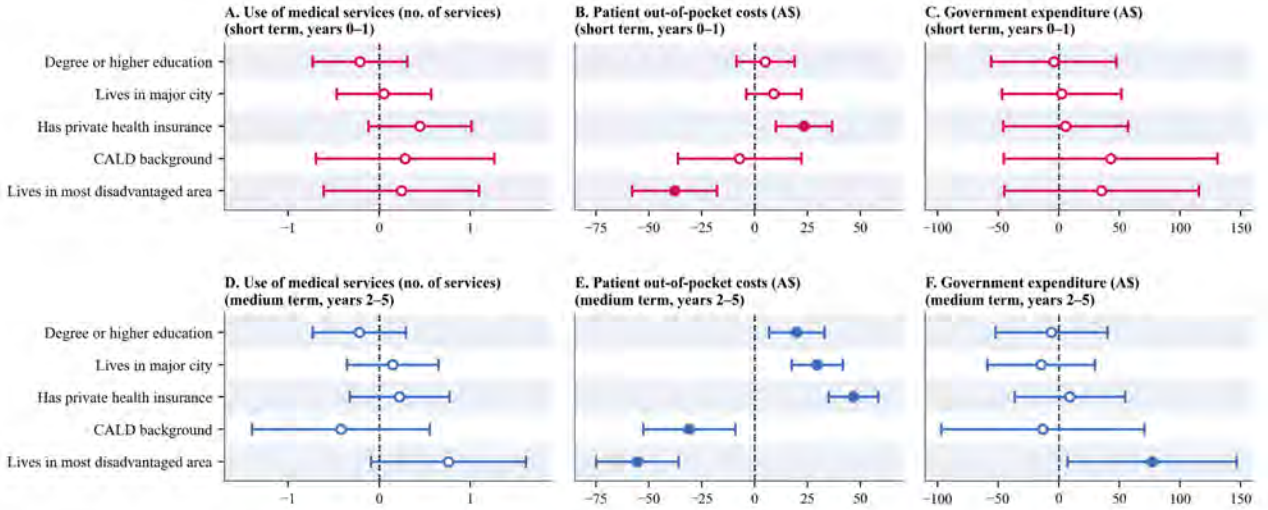
Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched male controls and the pre-menopause years τ=-4 and -3 as the reference period, with 95% confidence intervals. All outcomes are binary, so estimates are changes in probability expressed in percentage points. Filled markers denote estimates whose confidence interval excludes zero. Diagnosed health conditions are self-reported and collected from the three surveys of the 45 and Up Study. Physical and emotional functioning are summarised here by the 'any limitation' indicators; estimates for the individual items, and for all outcomes shown, are reported in Appendix Table A5.

Figure 4. Changes in the costs of medical services around menopause.



Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and τ=-3 as the reference year, with 95% confidence intervals. Costs are in 2022 Australian dollars. Panel A shows the total cost of medical services. Panel B plots government expenditure (Medicare rebates paid) and patient out-of-pocket costs on a common axis; the two sum to the total in Panel A.

Figure 5. Heterogeneous effects of menopause on service use and costs



Notes: Each marker is the interaction between the treatment-by-post indicator and the baseline characteristic shown, estimated from the pooled specification using age-matched male controls, with 95% confidence intervals. Panels A–C report short-term (years 0–1) effects and Panels D–F medium-term (years 2–5) effects; within each outcome the two panels share a common horizontal scale. Filled markers denote interactions whose confidence interval excludes zero. A positive coefficient means the increase in the outcome following menopause is larger for women with that characteristic. Costs are in 2022 Australian dollars. The menopause-age contrast is omitted here because it is estimated within the female panel rather than against male controls; it is reported, with all other estimates, in Appendix Table A8.

Tables

Table 1. Changes in non-hospital medical services used, by service category

Outcome	Outcome mean	Short-term (years 0–1)	Medium-term (years 2–5)
Total number of services	13.2	0.943***	0.036
		(0.141)	(0.148)
Number of GP visits	4.02	0.166***	-0.016
		(0.038)	(0.040)
Number of specialist visits	0.89	0.116***	0.048*
		(0.027)	(0.028)
Number of investigative services	6.33	0.526***	-0.003
		(0.084)	(0.088)
Number of therapeutic services	0.38	0.137***	0.019
		(0.030)	(0.026)

Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and the pre-menopause years τ=-4 and -3 as the reference period. Cells report the average annual effect over each horizon. Outcome mean is pre-menopause (averaged over years τ=-5, -4 and -3). Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Table 2. Changes in the costs of medical services, by service category and financing source

Outcome	Outcome mean	Total cost		Government		Out-of-pocket		Out-of-pocket share
		Short-term (years 0–1)	Medium-term (years 2–5)	Short-term (years 0–1)	Medium-term (years 2–5)	Short-term (years 0–1)	Medium-term (years 2–5)	Short-term (years 0–1)
All non-hospital services	1,008.1	82.699***	−9.515	62.456***	−20.844	20.243***	11.328***	24%
		(15.806)	(15.558)	(13.621)	(13.528)	(3.424)	(3.347)	
GP visits	268.7	18.077***	5.167*	11.083***	-0.670	6.995***	5.837***	39%
		(2.860)	(3.067)	(2.326)	(2.552)	(0.914)	(0.943)	
Specialist visits	149.9	20.485***	9.784	9.382*	1.844	11.102***	7.940***	54%
		(6.137)	(6.566)	(5.061)	(5.431)	(1.560)	(1.664)	
Investigative services	369.7	23.79***	-14.98**	24.06***	-8.83*	-0.29	-6.15***	-1%
		(5.98)	(5.87)	(5.27)	(5.24)	(1.31)	(1.20)	
Therapeutic services	64.8	25.994***	6.172	23.970***	4.811	2.024	1.361	8%
		(6.099)	(5.217)	(5.221)	(4.399)	(1.595)	(1.385)	

Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and the pre-menopause years τ=-4 and -3 as the reference period. Cells report average annual effects in Australian dollars over each horizon, expressed in 2022 prices. Outcome mean is pre-menopause (averaged over years τ=-5, -4 and -3). Standard errors, clustered at the individual level, in parentheses. The first row reports estimates for all non-hospital MBS services. The four categories shown do not exhaust total MBS cost: their pre-menopause means account for approximately 85% of total cost, the remainder comprising allied health and other unclassified services. Statistical significance: ***p<0.01, **p<0.05, *p<0.1. The final column reports the patient out-of-pocket component as a share of the total short-term effect for that category. The corresponding medium-term shares are not reported because several category totals are small and statistically indistinguishable from zero, which makes the ratio unstable.

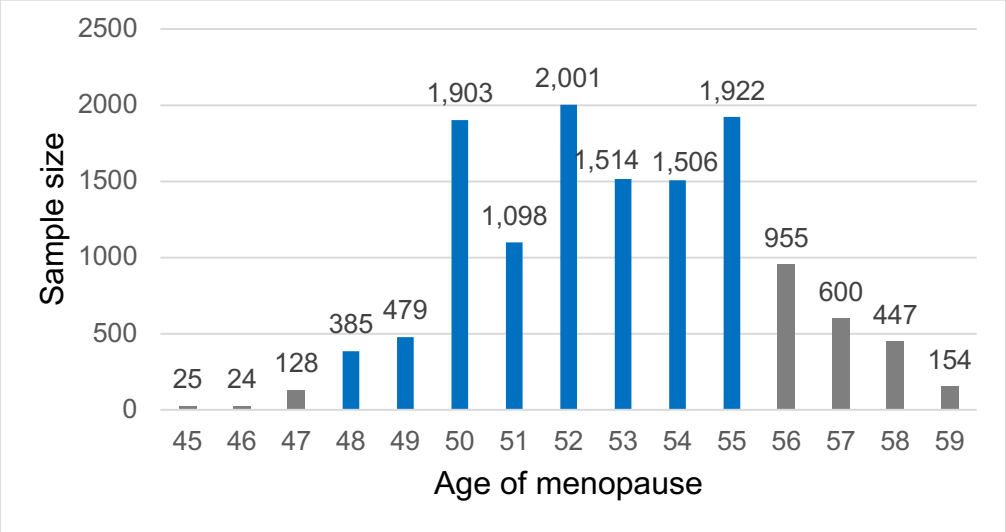
Table 3. Aggregate change in cost of medical services, per woman and per annual cohort of women reaching menopause

	Per woman (A$)			Per annual cohort (A$ million)		
	Total	Out-of-pocket	Government	Total	Out-of-pocket	Government
	(1)	(2)	(3)	(4)	(5)	(6)
Cumulative: years 0–1	199	46	153	34.0	7.9	26.1
	[138, 260]	[32, 60]	[100, 205]	[23.5, 44.4]	[5.5, 10.2]	[17.2, 35.1]
Cumulative: years 2–5	−5	48	−53	−0.8	8.3	−9.1
	[−128, 118]	[21, 75]	[−159, 53]	[−21.8, 20.2]	[3.6, 12.9]	[−27.2, 9.1]

Notes: Per-woman effects cumulate the annual event-study estimates for total cost, patient out-of-pocket cost and government expenditure reported in Appendix Table A2, in 2022 Australian dollars and without discounting. Aggregate figures scale these by 171,000 women, the approximate number of Australian women aged 52 (the median age of menopause in our sample) in 2026. Figures cover non-hospital MBS services only and therefore exclude pharmaceutical and hospital costs. 95% confidence intervals, in brackets, are computed from the covariance matrix of the event-study coefficients as linear combinations of the estimates in Appendix Table A2. The negative medium-term point estimates for government expenditure are not statistically distinguishable from zero.

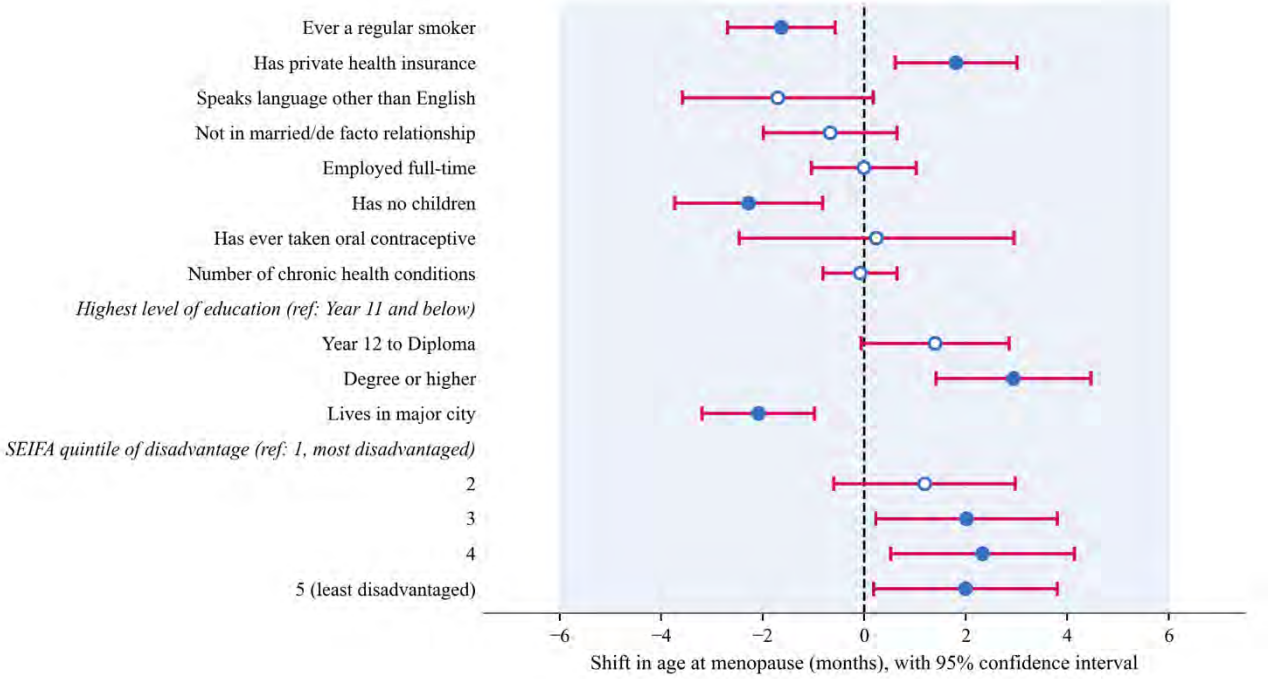
Appendix A. Additional Figures and Tables

Figure A1. Distribution of menopause age



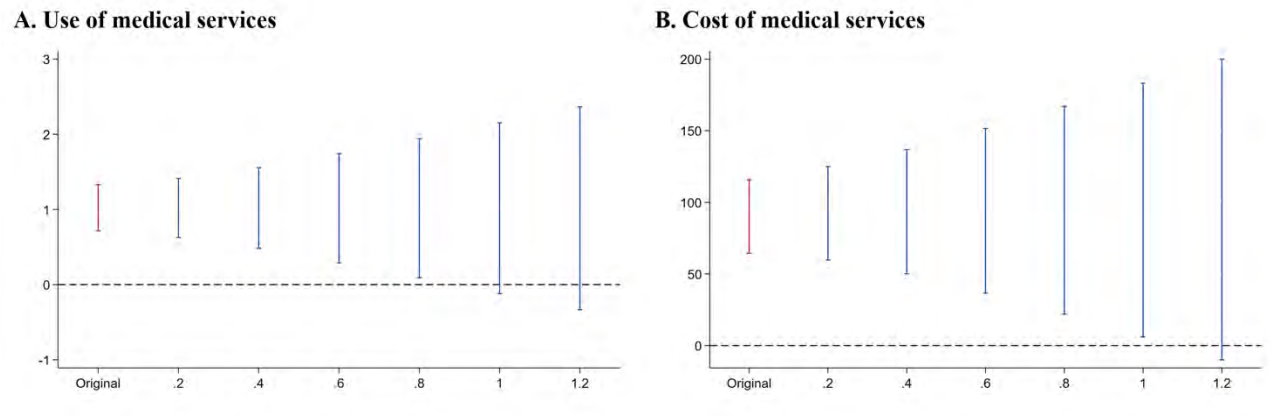
Note: Sample obtained from the three surveys of the 45 and Up Study (2006 to 2020).

Figure A2. Correlates of menopause age



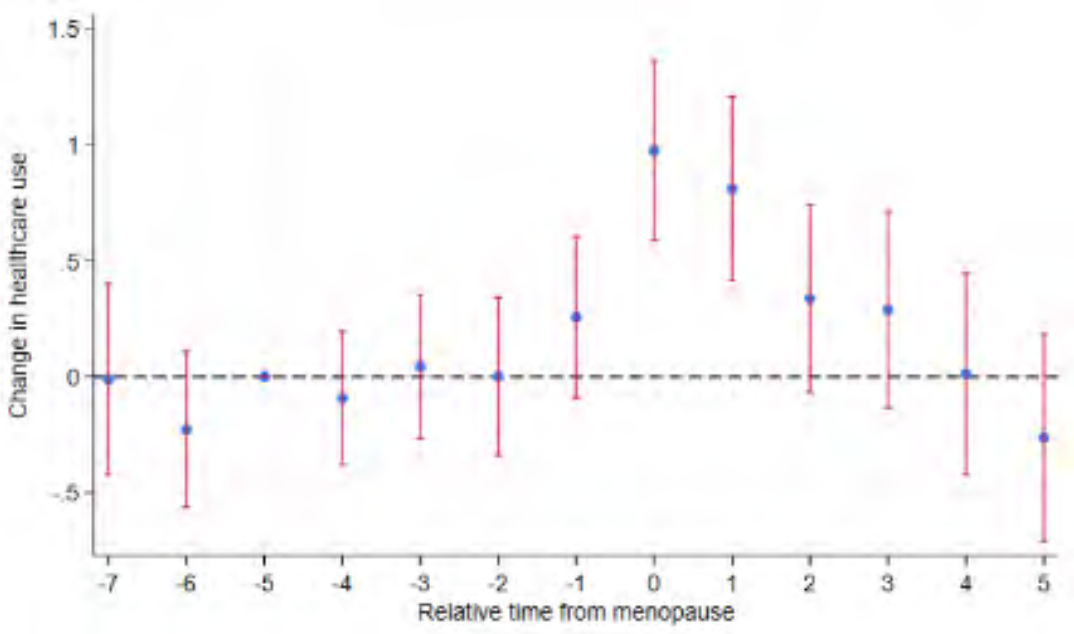
Notes: Estimates are from a linear regression of menopause age of women whose menopause onset was between 45 and 55 years of age, on baseline characteristics taken from Wave 1 of the 45 and Up Study survey, which for our sample occurred prior to menopause. Statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Figure A3. Test of sensitivity of results to violation of parallel trends



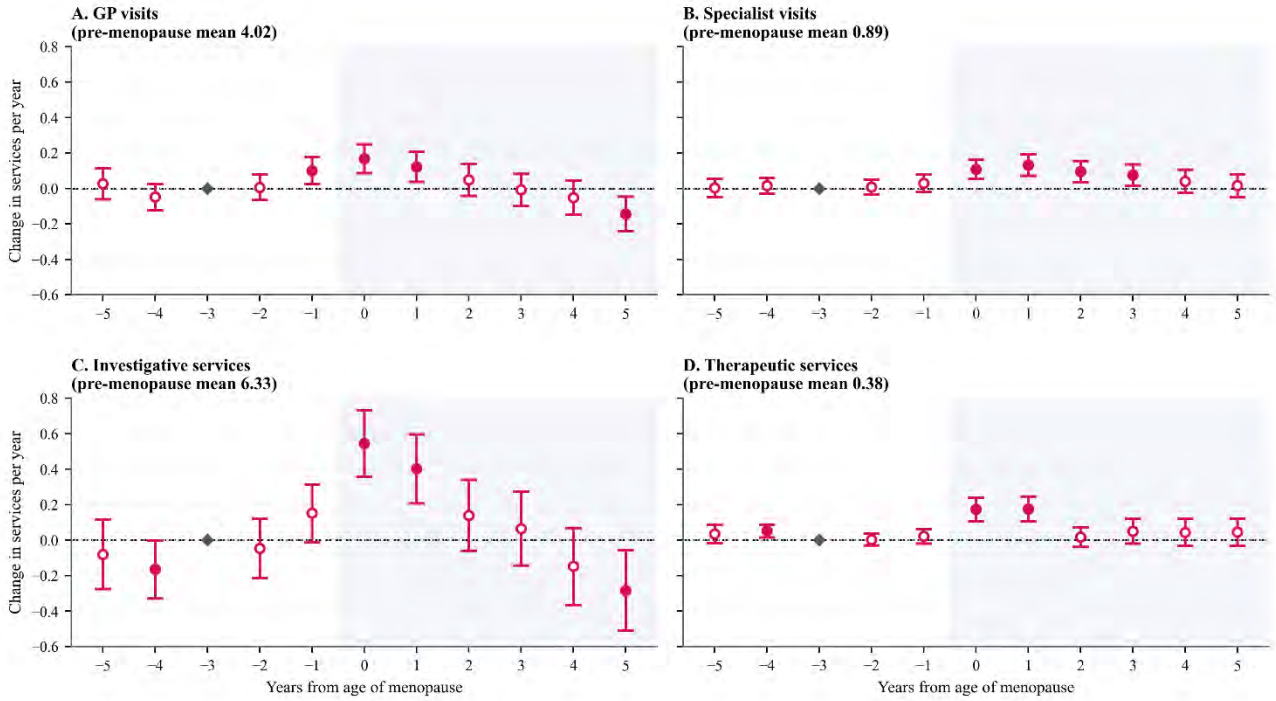
Notes: The figure presents evidence based on the Rambachan & Roth (2023) approach to testing the sensitivity of results to a violation of parallel trends, assuming that the bias induced by the violation in the post-treatment period is of a relative magnitude M compared to the pre-treatment period. Panel (a): total number of medical services; Panel (b): total cost of medical services. Estimates shown for the year of peak effects.

Figure A4. Extending pre-menopausal period of symptoms to 5 years



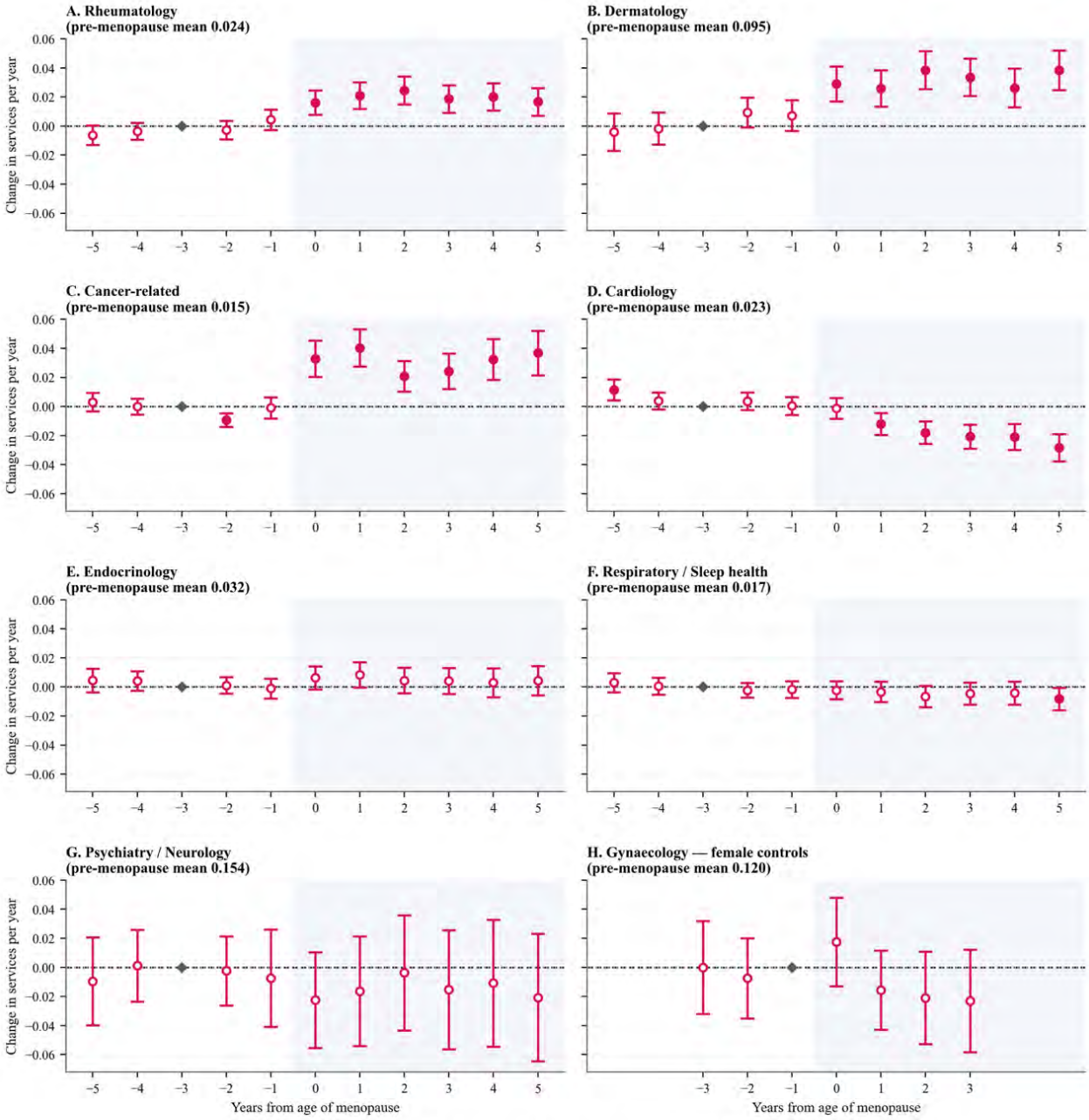
Notes: results from a stacked difference-in-difference model, using age-matched males as a control group and τ=-5 as the reference year.

Figure A5. Changes in non-hospital medical services by service category



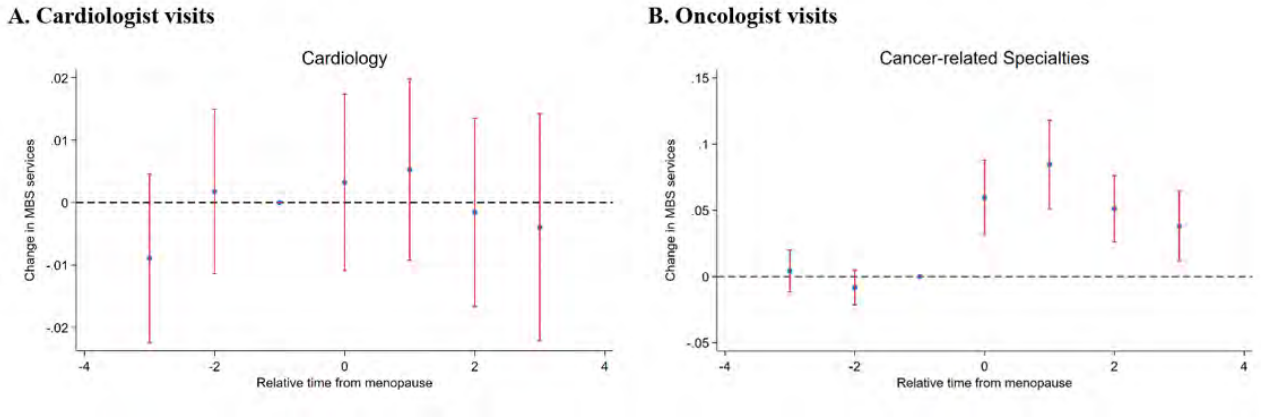
Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and τ=-3 as the reference year, with 95% confidence intervals. All four panels share a common vertical scale, and the pre-menopause mean from Table 1 is shown beneath each panel title. Filled markers denote estimates whose confidence interval excludes zero. The corresponding binned short- and medium-term estimates are reported in Table 1.

Figure A6. Changes in number of specialist services used around menopause by specialty



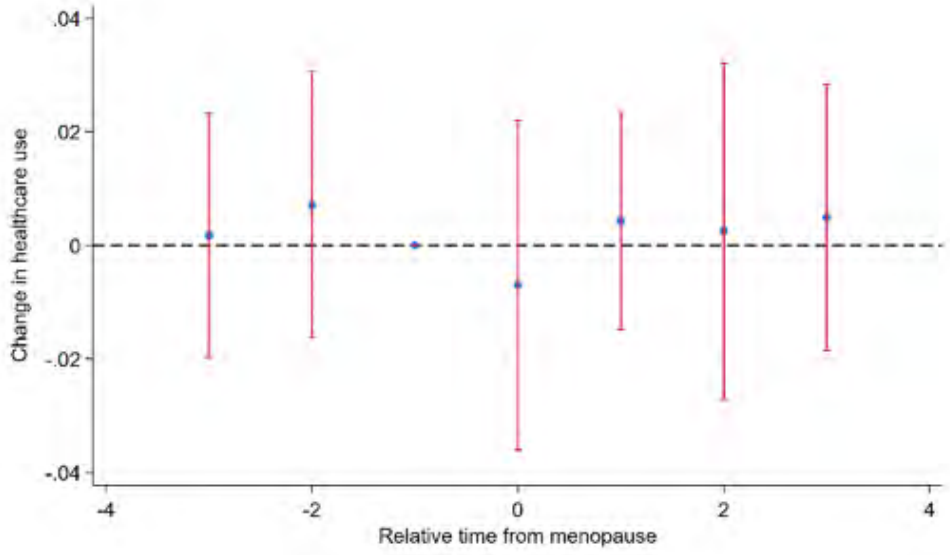
Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and τ=-3 as the reference year, with 95% confidence intervals. All eight panels share a common vertical scale. Panel H (gynaecology) uses the alternative control group of not-yet-treated women (Appendix B) with τ=-1 as the reference year, and is therefore estimated over a shorter window. The pre-menopause mean number of services per year is shown beneath each panel title. Filled markers denote estimates whose confidence interval excludes zero. The corresponding binned short- and medium-term estimates are reported in Appendix Table A4.

Figure A7. Changes in cardiologist and oncologist visits using not-yet-treated female controls



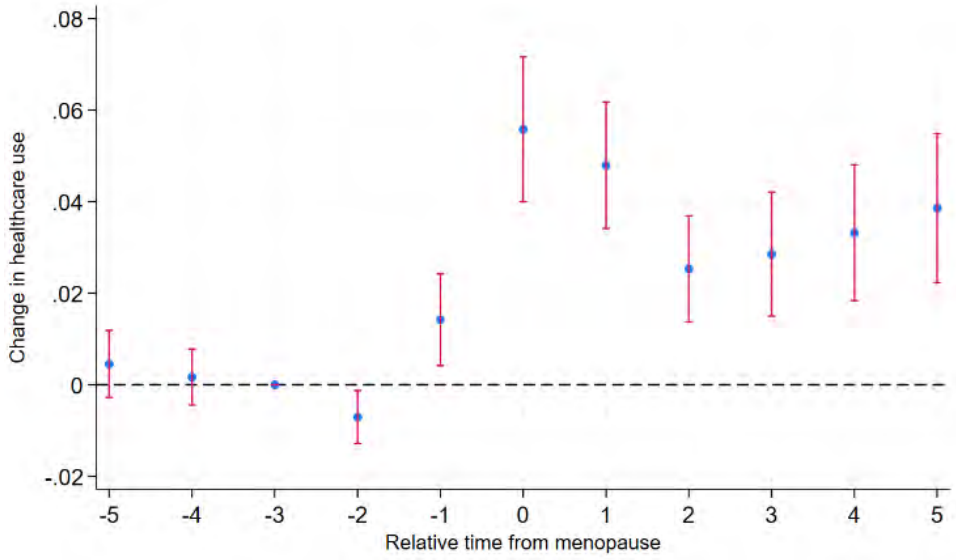
Notes: results from a stacked difference-in-difference model using an alternative control group of not-yet treated women. For each treated sub-cohort experiencing menopause at age *m* (m= 45,46, 47, 48, 49, 50, 51), the control group comprises women who experienced menopause five years later.

Figure A8. Changes in breast cancer screening using not-yet-treated female controls



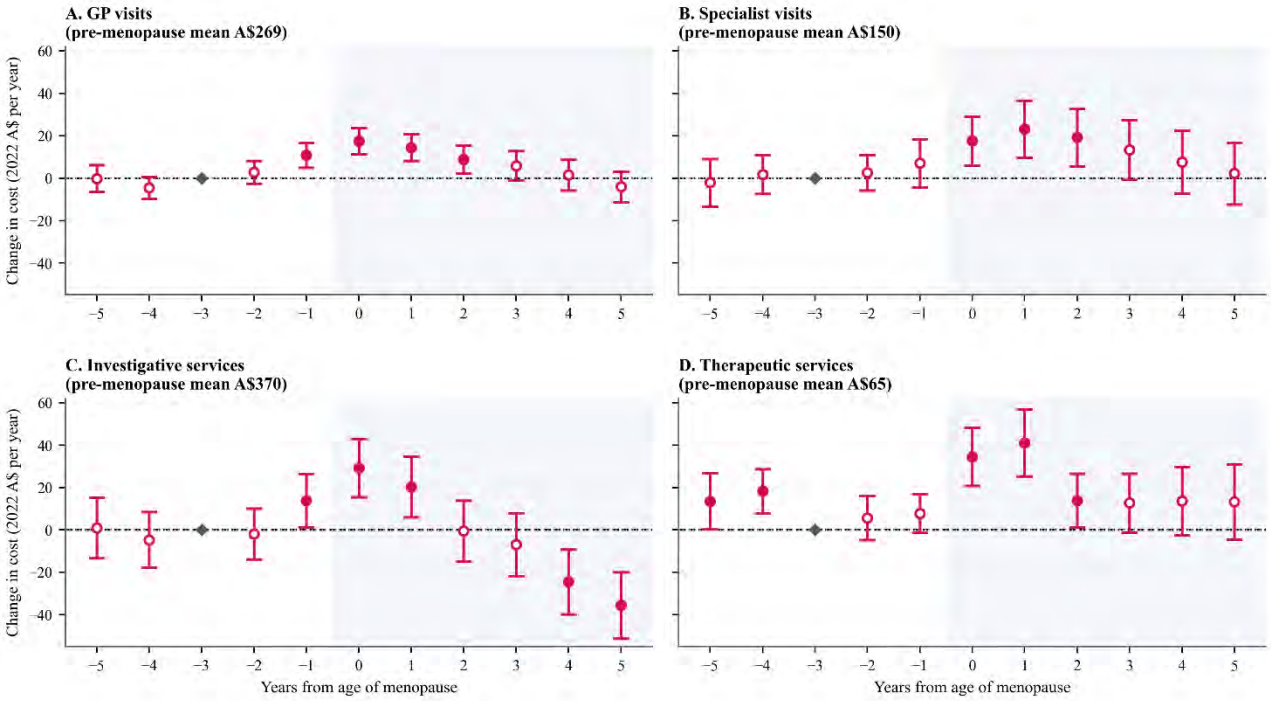
Notes: Results from a stacked difference-in-difference model using an alternative control group of not-yet-treated women, with τ=-1 as the reference year and 95% confidence intervals. For each treated sub-cohort experiencing menopause at age m (m = 45, …, 51), the control group comprises women who experienced menopause five years later. Screening is measured using linked breast cancer screening registry data.

Figure A9. Oncologist visits including patients diagnosed with cancer before menopause



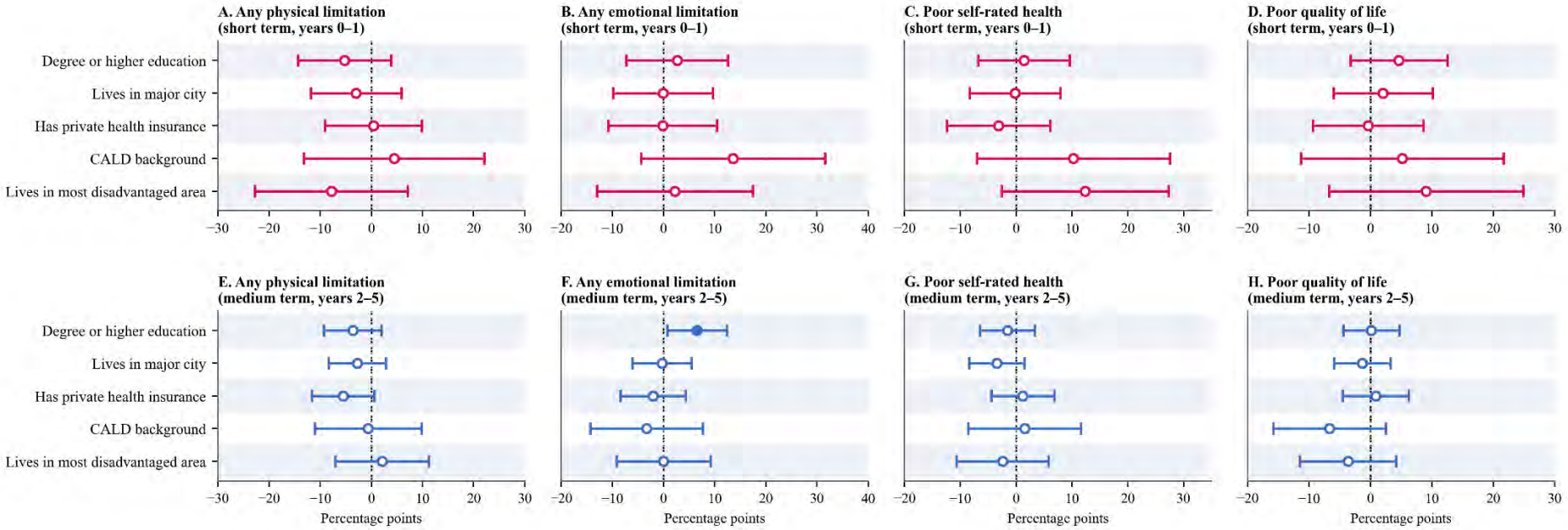
Notes: Results from stacked difference-in-difference models retaining those diagnosed with cancer prior to menopause using age-matched male controls.

Figure A10. Changes in total cost of medical services, by service category



Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and τ=-3 as the reference year, with 95% confidence intervals. Costs are in 2022 Australian dollars. All four panels share a common vertical scale, and the pre-menopause mean is shown beneath each panel title (averaged over years τ=-5, -4 and -3). Filled markers denote estimates whose confidence interval excludes zero. The corresponding binned short- and medium-term estimates are reported in Table 2.

Figure A11. Heterogeneous effects on self-reported health outcomes



Notes: Each marker is the interaction term between the treatment-by-post indicator and the baseline characteristic, from the pooled stacked difference-in-differences model with age-matched male controls (Section 4), estimated separately for the short-term (years 0–1 after menopause, Panels A–D) and the medium-term (years 2–5, Panels E–H), both relative to years −4 to −3. Outcomes are 0/1 indicators from the 45 and Up questionnaire and effects are in percentage points: any physical limitation and any emotional limitation are one if any of the ten physical or seven emotional items is reported; poor self-rated health and poor quality of life are one if rated good, fair or poor. Within each column the two panels share a common scale. Horizontal bars are 95% confidence intervals with standard errors clustered at the individual level; filled markers denote interactions whose confidence interval excludes zero. The most disadvantaged area interaction compares SEIFA quintile 1 with quintile 5 and is estimated on those two quintiles only.

Table A1. Baseline characteristics by treatment and control group status

	A: Male control		B: Female control	
Baseline characteristics	Treatment	Control	Treatment	Control
Single/Widowed (%)	19.0	18.4	20.2	18.6
Lives in major city (%)	54.2	55.6	55.3	53.6
Has private health insurance (%)	71.3	67.3	68.7	72.0
Speaks language other than English (%)	8.3	11.4	9.2	8.1
Did not have children (%)	14.4	15.8	15.7	14.4
Quintile of SEIFA disadvantage (%)				
1 (Most disadvantaged)	14.5	17.7	16.0	13.8
2	19.4	19.5	20.4	19.0
3	19.2	19.5	18.6	19.5
4	20.1	18.6	19.5	20.4
5 (Least disadvantaged)	26.8	24.7	25.4	27.3
Highest qualification (%)				
Year 11 and below	17.9	17.6	19.6	16.9
Year 12 High School to Diploma	42.8	49.7	44.1	42.5
Degree and above	39.3	32.7	36.3	40.7
Number of unique individuals	10,743	60,753	1,440	10,231

Notes: In panel A treatment group includes women who experience natural menopause between ages 45 and 55 during the study period. Control group includes males who are age-matched to the treatment group. Characteristics are collected at Wave 1 of the 45 and Up Study survey, which for all treatment women, occurs prior to menopause. In panel B treatment group comprises women who experienced natural menopause at ages 45 to 51; the control group comprises women who experienced menopause five years later (Appendix B). Characteristics are collected at Wave 1 of the 45 and Up Study survey.

Table A2. Event-study DID estimates using male control group

Years from age of menopause	Total medical services	Total cost of medical services	Patient out-of-pocket cost	Government cost
-5	0.025	21.250	-3.388	24.639*
	(0.153)	(15.899)	(3.934)	(13.044)
-4	-0.105	20.557	2.549	18.008
	(0.128)	(13.723)	(3.693)	(11.091)
-3	-	-	-	-
-2	-0.062	3.382	6.909*	-3.527
	(0.128)	(12.873)	(4.014)	(10.226)
-1	0.229*	33.662**	12.532***	21.130*
	(0.131)	(13.871)	(3.440)	(11.578)
0	1.023***	100.464***	22.169***	78.294***
	(0.157)	(16.931)	(3.827)	(14.474)
1	0.871***	98.246***	23.804***	74.441***
	(0.164)	(18.513)	(4.139)	(15.852)
2	0.306*	35.281**	21.857***	13.424
	(0.165)	(17.658)	(4.182)	(14.979)
3	0.142	9.905	16.780***	-6.875
	(0.174)	(18.239)	(4.190)	(15.689)
4	-0.087	-10.537	5.136	-15.672
	(0.182)	(19.656)	(4.253)	(16.988)
5	-0.347*	-39.419*	4.490	-43.909**
	(0.191)	(20.482)	(4.484)	(17.703)
Outcome mean	13.2	1,008.1	202.4	805.7
Observations	2,936,352	2,936,352	2,936,352	2,936,352

Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and τ=-3 as the reference year. Cost outcomes are expressed in 2022 Australian dollars. Outcome mean is pre-menopause (averaged over years τ=-5, -4 and -3). Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1

Table A3. Event-study DID estimates using female control group

Years from age of menopause	Total medical services	Total cost of medical services	Patient out-of-pocket cost	Government cost
-3	-0.213	-32.691	-2.173	-30.518
	(0.309)	(32.857)	(8.297)	(26.899)
-2	-0.366	4.926	18.543	-13.617
	(0.262)	(32.182)	(11.942)	(24.003)
-1	-	-	-	-
0	1.041***	109.548***	21.312***	88.236***
	(0.320)	(34.660)	(8.266)	(29.148)
1	1.123***	119.451***	16.978**	102.473***
	(0.316)	(36.313)	(8.106)	(30.884)
2	0.175	27.244	11.155	16.089
	(0.339)	(36.635)	(8.938)	(30.717)
3	-0.286	-10.597	6.081	-16.677
	(0.365)	(35.377)	(8.888)	(29.631)
Outcome mean	13.8	1,042.2	201.9	840.2
No. observations	72,677	72,677	72,677	72,677

Notes: Results from a stacked difference-in-difference model using an alternative control group of not-yet-treated women (Appendix B), with τ=-1 as the reference year. For each treated sub-cohort experiencing menopause at age m (m = 45, …, 51), the control group comprises women who experienced menopause five years later. Outcome mean is pre-menopause (averaged over years τ=-3, -2 and -1). Cost outcomes are expressed in 2022 Australian dollars. Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Table A4. Changes in number of specialist services used by specialty

Specialty	Outcome mean	Short-term (years 0–1)	Medium-term (years 2–5)	q-value (short-term)	q-value (medium-term)
Rheumatology	0.024	0.020***	0.022***	<0.001	<0.001
		(0.004)	(0.004)		
Psychiatry / Neurology	0.154	-0.021	-0.010	0.341	0.641
		(0.018)	(0.020)		
Respiratory / Sleep health	0.017	-0.003	-0.006*	0.354	0.099
		(0.003)	(0.003)		
Cancer-related	0.015	0.034***	0.029***	<0.001	<0.001
		(0.006)	(0.006)		
Endocrinology	0.032	0.005	0.002	0.334	0.641
		(0.004)	(0.004)		
Cardiology	0.023	-0.007**	-0.023***	0.058	<0.001
		(0.003)	(0.004)		
Dermatology	0.095	0.030***	0.033***	<0.001	<0.001
		(0.005)	(0.005)		
Gynaecology^	0.120	0.008	-0.015	0.641	0.425
		(0.016)	(0.016)		

Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and the pre-menopause years τ=-4 and -3 as the reference period. ^Gynaecology results from a stacked difference-in-difference model using an alternative control group of not-yet-treated women, see Appendix B for details. Outcome mean is pre-menopause (averaged over years τ=-5, -4 and -3 using the male control group and τ=-3, -2 and -1 using the not-yet-treated female control group). Statistical significance: ***p<0.01, **p<0.05, *p<0.1. Standard errors, clustered at the individual level, in parentheses. q-values are Benjamini-Hochberg false-discovery-rate adjustments computed across the 16 tests reported in this table (eight specialties by two horizons). Significance stars refer to unadjusted p-values.

Table A5. Changes in health outcomes in the short- and medium-term using age-matched male controls

Health outcome	Short-term (years 0–1)	Medium-term (years 2–5)	q-value (short-term)	q-value (medium-term)
Ever received a diagnosis of …				
Arthritis	0.009	0.015**	0.656	0.081
	(0.009)	(0.006)		
Asthma	-0.002	0.001	0.988	0.988
	(0.011)	(0.007)		
Depression	-0.011	0.011	0.689	0.656
	(0.014)	(0.010)		
Diabetes	-0.009	-0.018***	0.286	0.002
	(0.005)	(0.005)		
High blood pressure	-0.004	-0.010	0.988	0.656
	(0.014)	(0.010)		
Heart disease	0.007	0.003	0.687	0.918
	(0.008)	(0.006)		
Osteoporosis	0.007	0.017***	0.621	0.001
	(0.006)	(0.005)		
Cancer	−0.010	−0.002	0.684	0.988
	(0.011)	(0.008)		
Limitation in physical functioning				
Any physical limitation	0.055**	0.070***	0.070	<0.001
	(0.023)	(0.015)		
Walking 1km	0.033**	-0.001	0.070	0.988
	(0.014)	(0.009)		
Kneeling/bending	0.060***	0.053***	0.017	0.001
	(0.020)	(0.014)		
Lifting shopping	0.037**	0.029***	0.114	0.037
	(0.018)	(0.011)		
Climbing stairs	0.011	0.046***	0.793	0.001
	(0.019)	(0.012)		
Vigorous activity	0.050**	0.064***	0.114	0.001
	(0.024)	(0.016)		
Limitation in emotional functioning				
Any emotional limitation	0.018	-0.013	0.703	0.689
	(0.025)	(0.016)		
Feels depressed	0.006	0.011	0.967	0.656
	(0.015)	(0.011)		
Feels hopeless	-0.011	0.001	0.689	0.988
	(0.013)	(0.008)		
Feels nervous	0.014	0.026**	0.703	0.114
	(0.019)	(0.012)		
Feels worthless	0.000	-0.002	0.990	0.988
	(0.012)	(0.008)		
Overall health				
Poor self-reported health	-0.002	-0.012	0.988	0.689
	(0.021)	(0.014)		
Poor quality of life	0.001	0.002	0.988	0.988
	(0.021)	(0.013)		

Notes: Results from a stacked difference-in-difference model (Equation 1), using age-matched males as a control group and the pre-menopause years τ=-4 and -3 as the reference period. These estimates are plotted in Figure 3. Diagnosed health conditions are self-reported and collected from the three surveys of the 45 and Up Study. Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1. q-values are Benjamini-Hochberg false-discovery-rate adjustments computed across the 42 tests reported in this table (21 outcomes by two horizons). Significance stars refer to unadjusted p-values.

Table A6. Changes in diagnosed health conditions in the short- and medium-term using not-yet-treated female controls

Health outcome	Short-term (years 0–1)	Medium-term (years 2–3)
Arthritis	-0.029	0.025
	(0.111)	(0.017)
Depression	0.080	0.028
	(0.088)	(0.034)
Diabetes	0.048	0.012
	(0.069)	(0.014)
High blood pressure	0.072	-0.000
	(0.239)	(0.033)
Heart disease	-0.008	-0.008
	(0.081)	(0.015)
Osteoporosis	0.008	0.016
	(0.023)	(0.012)
Cancer	0.180	0.026
	(0.212)	(0.023)

Notes: Results from a stacked difference-in-difference model using an alternative control group of not-yet-treated women (Appendix B), with τ=-1 as the reference year. Outcomes are indicators for ever having received the diagnosis. None of the estimates is statistically distinguishable from zero. Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Table A7. Heterogeneity in the use of medical services by HRT use

	Short-term (years 0–1)	Medium-term (years 2–3)
Menopause × post (women never used HRT)	1.197***	−0.125
	(0.313)	(0.339)
Interaction × post (women ever used HRT)	−0.154	1.407**
	(0.554)	(0.651)
Implied effect for women ever used HRT	1.043	1.282
Share of women ever used HRT	16.8%	16.8%

Notes: Results from the pooled stacked difference-in-differences specification using not-yet-treated female controls (Appendix B). The outcome is the total number of non-hospital medical services. 'Menopause × post' is the effect for women who reported never using HRT; 'Interaction × post' is the differential effect for women who reported ever taking HRT. The implied effect for HRT users is the sum of the two. Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Table A8. Heterogeneous effects on service use and costs, full estimates

	Use of medical services		Out-of-pocket costs		Government expenditure	
	Years 0–1	Years 2–5	Years 0–1	Years 2–5	Years 0–1	Years 2–5
Degree or higher education						
Interaction × post	-0.211	-0.220	5.120	19.972***	-4.150	-6.091
	(0.265)	(0.261)	(6.996)	(6.647)	(26.283)	(23.571)
Menopause × post	1.032***	0.117	18.144***	3.126	62.953***	-18.871
	(0.181)	(0.179)	(4.133)	(3.904)	(16.676)	(16.103)
Menopause at age 50 or earlier^						
Interaction × post	0.449	0.646	12.079	-31.003	72.117	-102.286
	(0.634)	(1.478)	(16.057)	(33.018)	(62.130)	(157.871)
Menopause × post	3.892***	-1.322	55.250***	65.146**	209.476***	-74.340
	(0.856)	(1.174)	(17.642)	(32.388)	(69.276)	(107.750)
Lives in major city						
Interaction × post	0.053	0.148	9.098	29.624***	2.260	-14.570
	(0.265)	(0.257)	(6.654)	(6.193)	(25.034)	(22.624)
Menopause × post	0.932***	-0.020	15.490***	-4.800	60.387***	-11.889
	(0.195)	(0.191)	(4.582)	(4.085)	(16.628)	(16.104)
Has private health insurance						
Interaction × post	0.448	0.224	23.379***	46.739***	5.602	9.174
	(0.289)	(0.280)	(6.772)	(5.980)	(26.175)	(23.220)
Menopause × post	0.622**	-0.125	3.502	-22.142***	58.444***	-27.413
	(0.249)	(0.247)	(5.442)	(4.635)	(21.619)	(19.923)
CALD background						
Interaction × post	0.285	-0.420	-7.144	-30.929***	42.705	-13.279
	(0.499)	(0.499)	(14.889)	(11.096)	(44.860)	(42.693)
Menopause × post	0.920***	0.070	20.822***	13.833***	58.994***	-19.768
	(0.146)	(0.152)	(3.479)	(3.480)	(14.170)	(13.916)
Lives in most disadvantaged area (SEIFA)^^						
Interaction × post	0.244	0.760*	-37.850***	-55.487***	35.253	76.912**
	(0.435)	(0.435)	(10.279)	(9.944)	(40.876)	(35.591)
Menopause × post	1.023***	-0.081	39.989***	43.202***	62.748**	-32.792
	(0.272)	(0.259)	(7.847)	(7.712)	(30.234)	(26.761)

Notes: Each panel reports estimates from the pooled specification augmented with an interaction between the treatment-by-post indicator and the baseline characteristic shown, using age-matched male controls, estimated separately for the short-term (years 0–1) and the medium-term (years 2–5). 'Interaction × post' is the differential effect for the group indicated; 'Menopause × post' is the effect for the omitted group. Cost outcomes are in 2022 Australian dollars. ^The menopause-age comparison is estimated within the female panel. ^^The SEIFA specification is estimated on women in the most and least disadvantaged quintiles only. These estimates are plotted in Figure 5. Standard errors, clustered at the individual level, in parentheses. Statistical significance: ***p<0.01, **p<0.05, *p<0.1.

Appendix B

Here we set out an alternative model using not-yet-menopausal women, which aligns with contemporary not-yet peer-reviewed papers (Abrahamsson et al., 2025; Conti et al., 2026; Juarez and Marquez-Padilla, 2025). Within a difference-in-difference framework, we compare a treatment group who experience menopause at age m with a same-age counterfactual group who experience menopause at age m +Δ. Our baseline specification selects Δ=5, which enables estimation of treatment effects up to three years following menopause onset, allowing for a one-year pre-menopausal period during which healthcare use may change due to emerging symptoms. This one-year period is shorter than the three-years used in our main specification, to increase the number of cohorts available under this alternative approach.

Due to the potential importance of age of onset, we avoid pooling all menopause events in a standard event study. Rather, we follow Cengiz et al. (2019) and Deshpande and Li (2019) and construct seven event-specific sub-cohorts for women experiencing menopause at ages 45, 46, 47, 48, 49, 50, and 51, respectively. We exclude women experiencing menopause at older ages due to a lack of not-yet-menopausal control group individuals and construct menopause age-specific sub-cohorts. For women experiencing menopause at age *m* (e.g. 50), the control group comprises those who experienced menopause at age *m*+Δ (i.e. 55). The counterfactual trend for the treatment group then spans outcomes from ages *m* – 3 to *m*+3 (i.e. 47 to 53), using pre-menopausal data only from the control group. Rather than measure relative time from the calendar year of the index event, we take relative time from menopause age *m*, and estimate the following for each sub-panel:

$$Y_{iat}^{m} = \sum_{\tau=-3}^{3} \alpha_{\tau m} I_{it}^{\tau m} I_{i}^{m} + \mu_i + \delta_t + \gamma_{am} + \varepsilon_{iatm}$$

Where Y_{iat}^{m} is the outcome for individual *i* at age *a* in calendar year *t,* in the sub-panel where the treated group experienced menopause at age $m \in [45{,}51]$. $I_{it}^{\tau m}$ are indicator variables equal to 1 if the observation at age *a* occurred τ years from age *m,* $\tau \in [-3{,}3]$. The reference period is set to $\tau = -1$. I_{i}^{m} is an indicator variable denoting the treatment group comprising women who experienced menopause at age *m*. We include individual, age and year fixed effects, μ_i , γ_{am} and δ_t. Note that age fixed effects are allowed to vary across subpanels, whereas each individual appears in one sub-cohort only, and year effects are assumed constant across sub-cohorts. The coefficients of interest are $\alpha_{\tau m}$, representing the treatment effects τ years from menopause for women who experienced menopause at age *m*. The sample for this approach comprises 11,671 women contributing 72,677 person-years, 26,873 treatment and 45,804 control.