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The Illness Trap: The Impact of Disability Benefits on Willingness to Receive HCV Treatment

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The Illness Trap: The Impact of Disability Benefits on Willingness to Receive HCV Treatment

Abstract

Health care is assumed to be a primary good, implying that patients should always demand or accept treatments that may enhance their life expectancy and quality of life, especially if the risks associated with the treatment are low. We argue that, especially in countries with a well-developed welfare state, treating an invalidating condition may lead to opportunity costs in terms of reduced disability allowances that may represent a barrier to treatment for low-income individuals. We test this hypothesis by applying a recursive bivariate probit approach to population data from an ad hoc administrative database for Liguria (an Italian administrative region). The dataset includes data for more than 8 thousand people affected by hepatitis C Virus (HCV) infection between 2013 and 2020. After the discovery of new direct-acting antivirals (DAAs) in 2014, HCV eradication may now be possible. However, despite the national and international efforts, several patients diagnosed with HCV choose not to undergo drug therapy despite the adverse consequences for their personal health and relevant costs to the national health system. We show that five years after the implementation of the new drugs, approximately 41% of the diagnosed population in Liguria remains untreated. This percentage increases to 64% within the subgroup entitled to disability benefits and characterized by lower income levels. The “illness trap” effect is more substantial for older people but also low-income patients. Moreover, we find that this effect is higher in patients with an intermediate range of comorbidities; indeed, these patients are at a higher risk of losing economic benefits if they recover from HCV. These results suggest the need for healthcare policies addressing this distorting effect when designing benefit programs and granting financial benefits to patients.

Keywords: HCV, disability benefits, distorting effect, DAA;

JEL classification: I12, I38, H20, I19

1. Introduction

Traditional literature on health care assumes that health is a primary good, implying that individuals are expected to improve or preserve their health whenever possible (Zweifel et al., 2009). That is, this assumption implies that patients should always demand or accept treatments that may enhance their life expectancy and quality of life, particularly if the risks associated with the treatment are low. However, healthcare uptake is not evenly distributed across the population, even in public healthcare systems, where care is free at the point of use. These disparities may arise for several reasons, including health literacy, healthcare deserts, inability to pay, and other barriers (Amstislavski et al., 2012; Leporatti et al., 2021; Mehta et al., 2008; Di Novi et al., 2020a). A common characteristic of these studies on inequalities of access is that patients may be willing to accept care, but certain barriers may prevent them from being treated. In other words, while individuals should ideally refrain from choosing to trade their health stock for other goods and services, the literature on risky behaviors and drug use has already shown that people can and *do* rationally choose to trade off future health for present utility (Viinikainen et al., 2022). Considering this, it is important to study whether individuals may also give up treatment to obtain financial benefits. The trade-off between health care and economic benefits has not been well studied, but this aspect may be relevant in countries where the welfare state is well developed and generous because the system creates an opportunity cost for patients accepting treatment. We argue that in-kind redistribution (the provision of services for free) and subsidies (such as unemployment and disability benefits and social pensions) may, in fact, create an “illness trap” for economically deprived individuals.

Further, we argue that the fundamental explanation for this paradox may be patients’ perceived risk of losing the illness-related benefits provided by the welfare state. We use hepatitis C Virus (HCV) uptake data to demonstrate that a generous welfare state may trap people in illness.

Since 2014, the global introduction of a new generation of direct-acting antivirals (DAAs) has transformed the hepatitis C Virus (HCV) therapy approach and the possibility of recovery for patients is now close to 95% (Casey et al., 2019; Luo et al., 2019; Pol and Parlati, 2018). Accordingly, the World Health Organization is committed to eradicating hepatitis C by 2030 (WHO, 2022, 2016). Despite massive screening campaigns aimed at reaching the entire population with HCV and the possibility of using DAAs as free pharmacological treatments, a large percentage of the population has not received these new therapies, elongating the eradication of HCV. HCV causes fatigue, and because most people affected by this condition are unable to work, most social security systems in Western countries grant those affected disability payments as income supplements. However, the

latter may create an “illness trap:” to obtain a monthly allowance, patients refuse to receive treatment and improve their health.

In this study, we test this hypothesis using population data from an *ad hoc* administrative database for Liguria, an Italian administrative region. The dataset includes healthcare flows and entitlements for disability benefits for more than 8 thousand people affected by the HCV infection between 2013 and 2020. Notably, five¹ years after the implementation of the new drugs, approximately 41% of the diagnosed population in Liguria remains untreated. This percentage increases to 64% within the subgroup entitled to disability benefits and characterized by lower income levels.

We show that being entitled to disability benefits has a positive high and statistically significant effect on the probability of not receiving the treatment, with an average marginal effect equal to 41%; this effect is amplified among low-income individuals (marginal effect = 53%), suggesting that the willingness to be treated may be lower for those people more scared of losing economic benefits.

This paper contributes to existing literature in several ways. First, although there is rich literature on poverty traps and the definition of income support instruments, studies on how such subsidies can change individuals’ choices to seek treatment are not well developed. However, the topic is particularly relevant and interesting considering that the healthcare sector is highly innovative, and we expect that ailments currently considered chronic will become curable in the coming years. Therefore, it is plausible that HCV infection is the first conditions to be examined, among a series of case studies, to analyze the impact of welfare state systems on patients’ choices of treatments.

2. Related literature

2.1 Disability benefits and health choices

Social benefits are used to support people who experience deterioration in health, working ability, and family or economic conditions; however, their effects are controversial. The literature suggests that some financial incentives may influence people toward healthier behaviors (Vlaev et al., 2019). In contrast, several studies have shown that generous unemployment benefits may reduce the probability of entering the workforce, especially in economies characterized by informal work (Liepmann and Pignatti, 2021; Ståhl et al., 2023), or that disability benefits may hinder work resumption after recovery (Koning et al., 2022).

¹ In Italy, new DAAs became fully reimbursement in 2015, following the Italian Medicines Agency (Aifa) deliberation (Aifa, 2014).

The literature has largely focused on the effect of disability allowances on work incentives to design schemes that keep people with impairments in the labor market. These studies suggest that generous benefits tend to have a disincentivizing effect on resuming work (Koning et al., 2022) and, more generally, on participating in the labor market (Chen and van der Klaauw, 2008; French and Song, 2014; Maestas et al., 2013).

Another strand of psychological literature (e.g., Fraenkel et al., 2012; Mazzocco et al., 2019; Pravettoni et al., 2016; Savioni and Triberti, 2020; Szekely and Miu, 2015), considers some cognitive bias in choosing to undertake treatment or adhering to therapy. Such literature highlights that patients often have to make vital decisions while in an emotional state that may lead them to suboptimal decisions. In this context, we can argue that entitlement to economic aid (especially for income-deprived individuals) might cause these patients to prioritize disability benefits over their recovery and health status.

The literature on the effects of unemployment and disability allowances on health is scant and does not explicitly consider patients' likelihood of giving up treatment (e.g., Lantis and Teahan, 2018). We seek to bridge this gap by testing for the existence of a different disability trap, namely avoiding treating (possibly) fatal diseases to receive an economic benefit.

2.2 The Italian context

The Italian welfare system is highly structured but also quite complicated, especially concerning the rules governing qualification for receiving disability allowances. Disability benefits are generally awarded to patients suffering from specific (often chronic) physical and mental conditions (e.g., diabetes, HCV, and neoplasms). The recognition of one's disability level (from 0% to 100%) is dependent on the number and type of medical conditions. In 1992, the Ministry of Health defined the percentages of disability that are attributable to each medical condition (Law no. 104; February 5, 1992)²; these may be fixed (e.g., 51% for chronic active hepatitis³) or a range within the same pathology. This ministry has established that for some diseases (e.g., diabetes mellitus), the percentage of disability should be verified by a physician and specified in a range between the minimum and maximum levels. Disability scores can be accumulated; therefore, a patient may have a high percentage of disability in the presence of severe pathology and multiple (even less severe) pathologies. However, determining disability scores is not straightforward, not only because some diseases may have a variable score (established case-by-case by a dedicated commission), but also

² In appendix A.1 we report Table A.1 where are reported the disability percentage ranges for diseases concerning Digestive systems (there are several tables in the decree one for each system).

³ Ministerial Decree, February 5, 1992.

because the final score is not a linear function of single scores attributed to each disease; usually, the Balthazard formula⁴ is adopted for this calculation.

After obtaining a certified disability level, patients must undergo periodic visits to assess and vary their disability levels (confirming, increasing, or decreasing disabilities)⁵. Patients' disability levels are crucial for determining their eligibility for disability benefits and amounts. In Italy, two leading economic benefits are offered to people with disabilities: disability pensions and constant attendance allowances.

The disability pension is an economic benefit provided to individuals with a 100% disability aged between 18 and 67 years, with an income not exceeding €17,050.42 (this threshold was updated for 2022).⁶ Eligible individuals receive an annual amount of approximately €3,800. At the age of 67 years, the benefit becomes a social pension.⁷ The National Institute of Social Security (INPS) regularly revises the benefits and income thresholds required to benefit from subsidies.⁸

The second economic benefit, regardless of income or age requirements, is the constant attendance allowance. Disabled individuals requiring the assistance of caregivers may receive this benefit. The monthly subsidy is approximately €527 (approximately €6.300 per year).⁹

The contribution of each disability to reaching the threshold to qualify for benefits is quite large (entailing considerable discretion), and more importantly, the marginal contribution in terms of points for an additional ailment is even larger. In this context, it may be difficult for patients to foresee the likely effect of an additional ailment (or the treatment of a preexisting one) on their likelihood of receiving a disability allowance. This may create a disability trap, especially for individuals at the low end of the income distribution, for whom the disability benefit is the only source of income, or

⁴ Council of Europe, 2002. Working Group on the Assessment of Person-Related Criteria for Allowances and Personal Assistance for People with Disabilities. Council of Europe Publishing.

⁵ In 2007, the Italian (Ministry of Economy and Finance, 2007) established a set of medical conditions that did not require periodic review (but HCV does not belong to this list).

⁶ Pensions for deaf and blind people are regulated separately.

⁷ A sentence of the Constitutional Court (n. 152 of 23/06/2020) ordered an increase of the monthly disability pension up to a maximum of approximately 368 euros for single individuals with an annual income less than 8,590 euros (this value rises to 14,675 if married). The age threshold for receiving this additional amount was reduced from 60 to 18 years old. With this increase, the monthly amount may reach the value of approximately 660 euros, equal to nearly 8,500 euros a year.

⁸ More details are available at:

<https://www.inps.it/prestazioni-servizi/pensione-di-inabilita-agli-invalidi-civili>,

<https://www.inps.it/prestazioni-servizi/indennita-di-accompagnamento-agli-invalidi-civili>.

⁹ The constant attendance allowance complements the disability allowance (civil disability pension). For example, a person with a monthly civil disability pension of approximately 660 euros and a monthly constant attendance allowance of 527 euros may reach an annual economic benefit of 14,800 euros.

for people who have been out of the job market for a considerable period as it may be difficult for them to find employment.

3. Hepatitis C: burden of disease and treatment

The hepatitis C disease has relevant epidemiological and economic burdens (Cacoub et al., 2016; Jukić and Kralj, 2017; Stepanova and Younossi, 2017; Thrift et al., 2017). According to the WHO¹⁰ (2023), approximately 58 million individuals worldwide live with chronic HCV infection, and approximately 1.5 million new infections are reported annually. In 2019, the WHO estimated that approximately 290,000 individuals succumbed to the disease, primarily due to complications such as cirrhosis and hepatocellular carcinoma, a form of primary liver cancer.

Despite these data, antiviral treatments for hepatitis C are highly effective in curing the disease and preventing long-term liver damage. Sofosbuvir was the first active drug introduced in 2014; since then, many drugs and combined associations have been commercialized.¹¹ Before the introduction of DAAs, the standard of care (SoC) (Ansaldi et al., 2022) mainly consisted of the uptake of interferons, which could be combined with ribavirin. The introduction of peginterferons (alfa-2a and alfa-2b) represents the first step forward. In Italy, although the first generation of DAAs was introduced in 2013, followed by improvements in sustained virological response (SVR), recovery has not always been achieved (Manzano-Robleda et al., 2015; Wilby et al., 2012). Due to a lower SVR (from 10% to 75% with boceprevir and telaprevir (Soardo, 2015)) and heavy side effects, complete recovery from HCV with pre-DAA drugs was difficult and sometimes possible only in some HCV genotypes¹². Since 2014, owing to the availability of new DAAs, the recovery rate has increased to approximately 95% (Casey et al., 2019; Luo et al., 2019; Pol and Parlati, 2018). Compared with interferon therapy, which has several side effects (Alsabbagh et al., 2013; Dusheiko, 1997; Manns et al., 2006; Russo and Fried, 2003), new DAAs show greater efficacy (Feld et al., 2015; Luo et al., 2019; Sandmann et al., 2019; Yang et al., 2019) and a decrease in mortality in patients with HCV and hepatocellular carcinoma (Kamp et al., 2019). Moreover, the new DAAs reduced hospitalization rates (Schanzer et al., 2018), especially those related to liver diseases, in patients with hepatic cirrhosis (Hill et al., 2018), thereby reducing NHS costs (Park et al., 2019).

Estimating the actual number of people affected by HCV is challenging, and screening to eradicate HCV has proven insufficient because not all patients diagnosed with HCV are willing to be treated.

¹⁰ For more details see: <https://www.who.int/news-room/fact-sheets/detail/hepatitis-c>

¹¹ See *Tables A.3* and *A.4* in the Appendix for more details.

¹² For these reasons, in the present study we consider patients alive after the introduction of the new DAAs who were treated with Pre-DAAs but never switched to the new therapy as untreated.

According to the WHO (2023)¹³, among those diagnosed with chronic HCV infection globally, only 62% (9.4 million) had undergone treatment with DAAs by the conclusion of 2019. Untreated HCV infection may lead to cirrhosis (20%–50%) and hepatocellular carcinoma (11%–19%) (Schwartz and Birnkrant, 2021). Sometimes, the only possible therapy is liver transplantation (Gee and Alexander, 2005), which implies high healthcare system costs. Furthermore, extrahepatic manifestations (Cacoub et al., 2016; Jukić and Kralj, 2017) may arise, and if neglected, HCV may lead to death. Despite this, HCV has proven difficult to eradicate. Particularly, despite the information and testing campaign (WHO, 2022, 2017, 2016), wherein patients are informed about and offered free treatment, patients refuse treatment. However, this phenomenon is paradoxical. Economic literature postulates that health is essential for patients, who should do anything to restore it. However, this assumption does not hold when patients offered free treatment prefer to live with an invalidating chronic disease instead of being treated. This effect may be driven by the likelihood of losing the disability benefit that the ailment entitles them to or the possibility of health gain being too low. In the first instance, the less transparent the disability allowance system, the more likely this effect.

In the Italian context, sofosbuvir, the innovative drug to treat HCV, was first introduced in Italy with the Italian Medicines Agency (Aifa) reimbursement deliberation in December 2014 (Aifa, 2014) and became fully available in 2015. Since then, HCV eradication has become feasible, in line with the 2030 target set by the WHO (WHO, 2017, 2016). National screening programs have been introduced to identify previously undiagnosed patients.¹⁴ Italian screening tests address the population born between 1969 and 1989, patients enrolled in public centers for addictions (SerDs), and inmates. To achieve the targets of these screening activities, budgets of € 30 million for 2020 and € 40.1 million for 2021 were allocated (Ministry of Health, 2021). Despite this massive screening campaign, a recent study on the Italian population (Ansaldi et al., 2022) has shown that approximately 30% of patients diagnosed with HCV did not undergo drug therapy¹⁵. One reason for this unwillingness to receive treatment may be the generosity of the welfare system for people with disabilities.

¹³ For more details see: <https://www.who.int/news-room/fact-sheets/detail/hepatitis-c>

¹⁴ Particularly with Law 8/20, which introduced a screening program on an experimental basis for 2020 and 2021.

¹⁵ The estimation of untreated in Ansaldi et al.'s (2022) study is different from the ones estimated in the present study for several reasons: (a) the study periods are different (2013–2018 vs. 2013–2020); (b) different inclusion criteria applied (such as, including or not patients died before 2015); (c) the more relevant reason is the different definition of “untreated” patients (different from Ansaldi et al. (2022), we consider also those who received pre-DAA therapy as “untreated” patients).

4. Dataset

This study addresses the regional administrative flows in Liguria, a northwestern region of Italy (1.5 million residents in 2023¹⁶), from 2013 to 2020. The final dataset contains a rich set of variables derived from different administrative health flows, including information on patient demographic characteristics, socioeconomic conditions, drug purchases, and the use of healthcare services. For each patient, we match information from the following registries:

- Hospital discharge records containing information about hospitalizations
- Emergency department (ED) visits - a registry of all patient visits to emergency departments
- Pharmaceutical registry - collecting information about drug purchases
- Registry of deaths
- Exemption database containing individual-specific information (e.g., exemptions due to chronic conditions)

All patient information is anonymized and linked using an id-code to guarantee privacy.

4.1 Inclusion criteria

This study combines two criteria to identify patients affected by HCV: (1) a diagnosis received during hospitalization or an ED visit, and (2) drug purchases.

We address all Ligurian patients over 15 years of age diagnosed with HCV during hospitalization or a visit to the emergency room during the 2013–2020 period and any patient using at least one DAA for treating HCV. *Table A.2 of Appendix A.2* reports the ICD-9-CM¹⁷ diagnostic codes used to identify patients diagnosed with HCV infection during hospitalization or an emergency room visit (e.g., chronic hepatitis C with or without hepatic coma). *Tables A.3 and A.4 (Appendix A.2)* report all drugs considered for HCV therapy. Drugs are split into therapy generally used before 2015 (i.e., “Pre-DAA drugs”) and therapy available after 2015 (i.e., “DAAs” drugs). We group the patients based on the following therapies: pre-DAAs, DAAs, Both, and None.

In the “Both” category, we include patients with at least one purchase of a pre-DAA drug and one DAA drug. We restrict the analysis to patients who were alive in 2015 (the year of the first DAA distribution in Italy). Since ribavirin (classified as a pre-DAA drug) cannot be considered an HCV therapy if assumed as monotherapy, we exclude all patients who only use ribavirin, unless they do not have an HCV diagnosis. In the case of an HCV diagnosis and the use of ribavirin only, we add

¹⁶ Source: Italian National Institute of Statistics (ISTAT, 2023)

¹⁷ International Classification of Diseases - 9th revision - Clinical Modification

the patient to the “None” therapy group. Moreover, the use of peginterferon alpha-2a for 48 weeks may signal hepatitis B (Ye and Chen, 2021). Therefore, in the absence of an HCV diagnosis, we exclude patients who only use peginterferon from 46 to 48 weeks.

To compare the ones treated without DAA therapies with the ones treated with DAAs, we classify the “DAAs” and “Both” categories as the “treated” group, and the “None” and “Pre-DAAs” categories as the “untreated” group. Further, we consider patients who use DAAs either with or without ribavirin.

Considering the “*defined daily dose*” (DDD)¹⁸, we exclude patients who did not purchase a therapy dose sufficient to cover the minimum period of therapy, which is 12 weeks (eight in the case of drugs with Anatomical Therapeutic Chemical (ATC) code “J05AX65,” “J05AP57,” or “J05AP56”) as indicated in each drug’s therapeutic indication sheet.

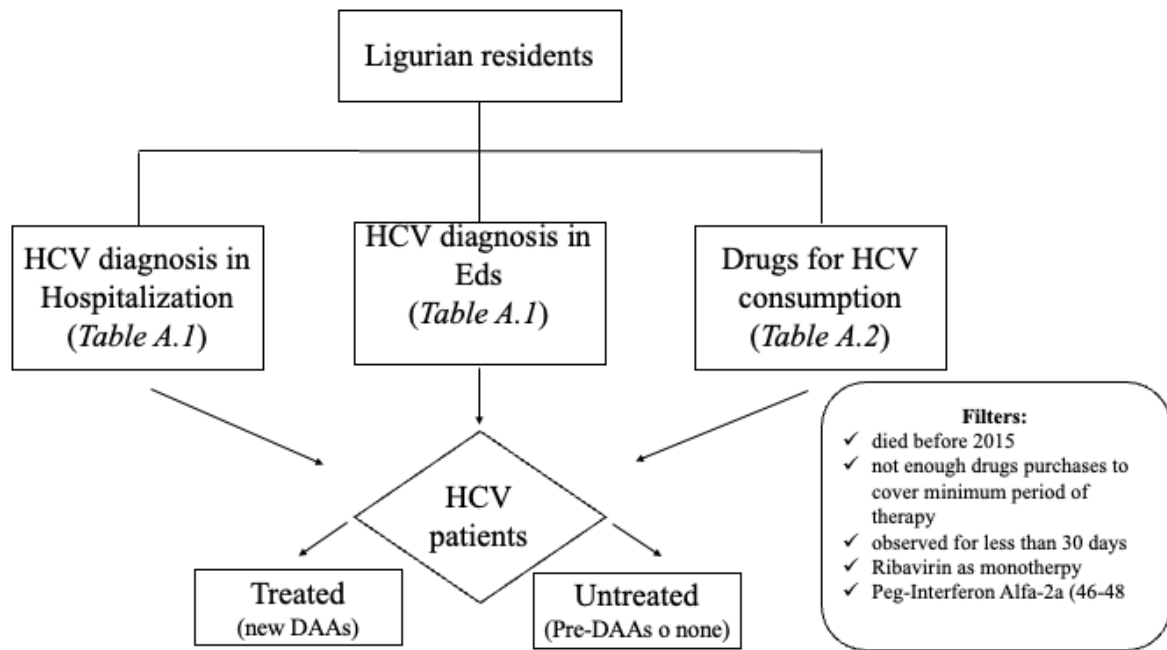
Finally, we exclude patients who were observed for less than 30 days because, on average, patients may express their intentions to receive treatment by buying at least one drug within one month.

Based on these inclusion criteria, we identified 8.365 patients affected by HCV infection in Liguria: 4.953 used DAA therapy, while 3.412 (40,8%) did not receive any treatment.

Figure 1 presents the inclusion criteria (see *Appendix A.2* for further details).

¹⁸ DDD is the average dose per day for a determined drug, considering the main indication in adults as the benchmark. For more details, see <https://www.who.int/tools/atc-ddd-toolkit/about-ddd>

Figure 1: Inclusion criteria



5. Empirical strategy

5.1 Outcome dependent variables

This study tests whether entitlement to disability benefits reduce the probability of receiving HCV treatment. To assess this effect, a simultaneous equation approach that considers the simultaneous relationship between treatment status (i.e., having received the new DAA drugs) and entitlement to disability benefits is required.

Following recent studies by Brugiavini et al. (2022) and Di Novi et al. (2023), we use a recursive bivariate probit model that corrects the potential endogeneity arising from including entitlement to disability benefits in the treatment status equation (Di Novi et al., 2020b) (see *Subsection 5.2*). We adopt a bivariate model in which one of the endogenous binary variables (i.e., entitlement to disability benefits) is included as a regressor in the other binary choice equation. This model is called "recursive" because it comprises two simultaneous equations with two dependent variables, one of which is also an endogenous variable in the first equation (Green, 2017).

The two outcome variables representing the two dependent variables of our recursive model are treatment status and entitlement to disability benefits. The treatment status variable is a dummy constructed to assume the value of 1 if the patient receives the new DAA treatment and 0 otherwise.

Patients treated only with pre-DAA drugs are considered not treated, since we would consider switching to a new (potentially curative) therapy from 2015 as intention to receive treatment. Entitlement¹⁹ to disability benefits is measured using a dummy variable that takes the value of 1 if the patient has an exemption due to 100% disability with or without a constant attendance allowance and 0 otherwise²⁰. We assume that those receiving economic benefits due to disability may be “afraid” of losing the benefits should they recover from HCV. Consequently, these patients may be less likely to undergo HCV treatment.

In robustness checks, we refine our variable to signal the presence of entitlement to disability benefits, restricting the dependent variable to the presence of entitlement to disability benefits before the Italian commercialization of DAAs (year 2015). Our hypothesis is that those who were already receiving a disability benefit before new therapies became available may be more disincentivized to receive treatment than those diagnosed after 2015. In fact, therapies prior to DAAs, although not curative, can still be used to manage chronicity. Therefore, patients receiving treatment before 2015 who are entitled to disability benefits may have a greater aversion to new therapies.

5.2 Econometric approach

The presence of endogeneity complicates the identification of the association between entitlement to disability benefits and the choice to receive HCV treatment. To account for potential simultaneous relation, we adopt a recursive bivariate probit model. The model consists of a two-equation system comprising a structural equation (Eq.(1)) and a reduced-form equation (Eq.(2)):

$$\begin{cases} y_{1i}^* = \alpha_0 + \alpha_1 y_{2i} + \alpha'_{2i} x_{1i} + \varepsilon_{1i} & [1] \\ y_{2i}^* = \beta_0 + \beta'_{2i} x_{2i} + \varepsilon_{2i} & [2] \end{cases}$$

where y_{1i} represents the treatment status (treated with DAAs or not), y_{2i} is the entitlement to disability benefits, x_{1i} is a vector of exogenous variables used as controls (e.g., age group, sex, exemption due to income, diagnosed before 2015, and substance abuse), and x_{2i} is a vector of exogenous variables used as controls in Eq.(1) and the instrumental variable vector z_{ji} ($j=1, 2, \dots, 15$). The intercept parameters are α_0 and β_0 , α_1 is a scalar parameter, and α'_{2i} and β'_{2i} are parameter vectors. Note that y_{2i} (i.e., entitlement to the disability benefit) is one of the explanatory variables in Eq.(1) and the dependent variable in Eq.(2); hence, at least one of the exogenous variables (x_{2i}) of

¹⁹ As explained in paragraph 2.2, to be entitled to an invalidity allowance, individuals with total disability certification must also satisfy some income threshold criteria. However, regardless of income level, they are entitled to other benefits such as ticket exemption (a ticket is a co-payment due when a person uses certain Italian healthcare services). In contrast, the constant attendance allowance is paid irrespective of income.

²⁰ We use two exemption codes: C01 total disability (100% disability) and C02 total disability (100% disability) with the constant attendance allowance.

the reduced-form model (Eq.(2)) should be omitted as an explanatory variable in the structural equation (Eq.(1)) (Maddala, 1983). Error terms (ε_{1i} and ε_{2i}) are normally distributed bivariates with mean 0 and variance-covariance matrix Σ (with value 0 on lead diagonal and correlation ρ_{12} on off diagonal elements). In the recursive bivariate probit model, the correlation coefficient ρ tests the independence of the equations; under our hypothesis, we assume that estimating the two equations independently is equal to estimating them simultaneously; that is, the error terms of the two equations are independent. Therefore, if ρ is significantly different from 0, we may assume that the two outcome variables in the model are not independent, and the recursive bivariate model is the right approach.

5.2.1 Identification strategy

Recursive bivariate probit model identification is conventionally based on imposing exclusion restrictions on the Instrumental variable (IV) selected to achieve a more robust identification of parameters (Maddala, 1983). More recently, the global identification of the parameters in a triangular system of two equations with exclusion restrictions has become necessary and sufficient in a model with instruments that are included in the equation for endogenous treatment variables but excluded from the outcome variable equation (Han and Vytlačil, 2017). This approach was recently followed by Brugiavini et al. 2022, Di Novi et al. 2023, Li et al., 2021, and Ochalek et al. 2017. For the identification of recursive bivariate probit model. Wilde (2000) pointed out that it is possible to achieve this even if both equations contain the same exogenous variables.

Because the use of an IV approach can lead to a loss of efficacy, we use both the Durbin and Wu–Hausman tests (Durbin, 1954; Hausman, 1978; Wu, 1974) to test for endogeneity²¹. Under H0, we assume that the considered variables can be treated as exogenous. In our analysis, the test is statistically significant; therefore, we can reject the null hypothesis and assess that the variables are endogenous, and an IV approach should be appropriate for this. We exploit a rich dataset to obtain two different comorbidity definitions, allowing us to test two model specifications using two different instruments (see *Section 5.3* for details on IV selection). The IVs are included in the reduced-form model but not in the structural equation because at least one exogenous variable in the reduced form should not be included in the structural form as an explanatory variable, as in (Maddala, 1983). Therefore, we set and control the exclusion restrictions (Maddala, 1983; Wilde, 2000).

²¹ We run endogeneity tests on IVs to assess if the IV approach is necessary or not since the choice of employing IVs entails a sacrifice in terms of efficacy. We use both Durbin and Wu–Hausman tests (Durbin, 1954; Hausman, 1978; Wu, 1974) to test for endogeneity. Under H0, we assume that the variables considered can be treated as exogenous. If the test is statistically significant, we can reject the null hypothesis, and we can assess that the variables are endogenous, and an IV approach should be appropriate.

We use STATA 18 software to estimate the recursive bivariate probit model using a simulated maximum likelihood estimation, in line with Cappellari and Jenkins (2003).

Stata software estimation also provides a correlation coefficient, a transformation of ρ ($\rho_{1,2}$), and captures the effect of unobserved heterogeneity (Filippini et al., 2018; Green, 2017; Isnaini et al., 2019; Di Novi et al., 2020). The following subsection describes the variables used in our estimation.

5.2.2 Exclusion restrictions

This section describes the exclusion restrictions used in the models. We adopt two different measures of health status as IVs, starting with information in the administrative dataset.

The presence of comorbidities is assessed using two approaches: the Charlson Comorbidity Index (CCI) and exemptions based on the chronic conditions registry.

The CCI is a weighted index introduced in 1987 (Charlson et al., 1987) to categorize patient comorbidities based on diagnostic codes (International Classification of Diseases, ICD). Each comorbidity is ranked by weight, from one to six. The sum of the weights results in a single score (0 indicates no comorbidities). The higher the score, the higher the mortality risk or probability of NHS resource utilization. This study computes the CCI using information from diagnosis codes during hospitalizations or access to emergency departments. By computing the CCI, we also detect specific chronic conditions (such as AIDS, diabetes, peripheral vascular disease, dementia, peptic ulcer disease, mild LD (liver), cancer, and metastatic cancer, among others). However, the principal limitation of using the CCI to assess health status is that we also need information on patients who did not use healthcare services (not hospitalized or visited EDs) during the study period. We complement these data with inputs from the registry of exemptions due to chronic conditions to partially mitigate this issue. In Italy, people with specific chronic conditions (such as HIV, psychosis, respiratory failure, glaucoma, epilepsy, multiple sclerosis, and Parkinson's disease) are exempt from paying for specific drugs for their pathology. Therefore, this information may provide a complete picture of the chronic pathologies in the study population.

The presence of comorbidities is then alternatively included in the model as an IV as the number of chronic diseases for each patient (variable *Sum_disease – Model 1*) or as a set of dummy variables testing the presence of specific groups of comorbidities, obtained by merging and grouping comorbidities from the CCI and the exemptions registry (e.g., diabetes, cardiac, HIV infection, and liver, kidney, and neurological diseases; see details in *Table 2*) (*Model 2*). From a theoretical perspective, comorbidities are crucial in determining entitlement to disability benefits, and the level

of disability strongly depends on the number and type of chronic conditions experienced by the patient (see *Section 2.2*).

To further assess the reliability of our IVs, we apply commonly used approaches. A reliable IV should indeed satisfy two conditions in terms of the “strength” of the instrument (i.e., it must be significantly correlated with the endogenous regressor) and validity of the instrument (i.e., it must be exogenous in the structural equation).

The weakness of the instrument is directly testable by regressing the endogenous explanatory variable on the IV(s) and all other exogenous variables from the structural equation and testing the significance of the coefficient for the instrument in the reduced-form equation. The F-test statistics for the significance of the coefficient of the *Sum_disease* variable (Model 1) and for the joint significance of the instruments (Model 2) are largely above 10, which is commonly viewed as the threshold for avoiding choosing “weak” instruments²² (Stock and Yogo, 2005).

We also estimate the minimum eigenvalue statistic proposed by Cragg & Donald (1993) and then discussed by Stock & Yogo (2005) to further test for weak instruments. All tests are in line with the threshold criteria. All the test results provide evidence in favor of our choice of instruments and support the hypothesis that the instruments are not weak.

Concerning instrument validity, the reduced-form model assumes that the *Sum_disease* and *Comorbidities* variables affect treatment status only indirectly through entitlement to disability benefits. We reasonably assume that having a high number of comorbidities or specific comorbidities should not affect the patient’s choice to receive DAA treatment. This is justified by the fact that the therapeutic indications for DAAs do not assume contraindications for using DAAs in the presence of other comorbidities.²³ Consequently, the IVs appear significantly correlated with the endogenous regressor but uncorrelated with the error term in the structural equation.

5.3 Other independent variables

A rich set of control variables (demographic and socioeconomic conditions) were included in the models. Age, sex, and citizenship are employed as demographic variables. The variable of particular interest is the exemption due to income or unemployment. Indeed, in the national healthcare system, there are exemptions related to individuals’ socioeconomic status. In particular, those who are over

²² F test statistics are respectively 988 and 77 (p-value <0.0001) for the 1st and 2nd baseline model instruments.

²³ In the presence of specific diseases (particularly psychiatric diseases), recommendations suggest access to DAAs under medical control because they may interact and lower the absorption of other drugs such as some anti-convulsions and epilepsy drugs.

65 and have an income below a certain threshold²⁴ and those who are unemployed and have an income below a set threshold are entitled to this exemption. Using this control variable allows us to identify patients who are economically vulnerable and who may be more interested in not losing their disability benefit. A dummy variable is also included to verify whether an HCV diagnosis occurred before the introduction of new DAAs. We argue that people receiving care from SerD²⁵ belong to a particular social group with a specific history. Hence, these patients may differ from others regarding therapy adherence. Consequently, we introduce a dummy variable for substance abuse as a proxy for belonging to this group.

Table 1 provides a complete description of the study variables.

Table 1: Description of the variables

Group	Variables	Description
<i>Outcome</i>	No treatment	Binary variable=1 if the patient is not treated with DAAs, and 0 if treated with DAA
<i>Demographics & socioeconomic characteristics</i>	Age group	Categorical variable: 0 if the patient's age is between 15 and 44 years; 1 if the patient's age is between 45 and 64 years; 2 if the patient's age is 65 years old and above
	Male	Binary variable=1 if the patient is male
	Italian citizen	Binary variable=1 if the patient is an Italian citizen, 0 otherwise
	Exemption due to income or unemployment	Binary variable=1 if the patient has an exemption due to an income below a certain threshold or due to unemployment, and 0 otherwise
	Entitled to disability benefits	Binary variable=1 if the patient has exemption due to 100% disability with or without constant attendance allowance, and 0 otherwise
	Entitled to disability benefits before 2015	Binary variable=1 if the patient has exemption due to 100% disability with or without constant attendance allowance before 2015, and 0 otherwise
	Entitled to disability benefits (without attendance allowance)	Binary variable=1 if the patient has exemption due to 100% disability without constant attendance allowance, and 0 otherwise
	Diagnosed before 2015	Binary variable=1 if the patient receives an HCV diagnosis before 2015, and 0 otherwise
<i>Health status</i>	Substance abuse	Binary variable=1 if the patient suffers from substance abuse, and 0 otherwise
	Charlson Index	Score of the CCI and the list of dummies for chronic disease

²⁴ As from 2023, the exemption code E01 is assigned to citizens aged under six and over 65, belonging to a family unit with a total annual income not exceeding 36,151.98 euros; the exemption code E02 is instead given to unemployed people and their dependent family members belonging to a family unit with a total yearly income of less than 8,263.31 euros, increased up to 11,362.05 euros in the presence of a spouse and at the rate of a further 516.46 euros for each dependent child.

²⁵ SerD stands for "Servizi per le Dipendenze," which means the Italian service for addiction (e.g., to drugs, alcohol, gambling)

Sum_ disease	Count variable. Merge comorbidities classified in the CCI with medical exemptions for each patient and group them into a homogeneous class
Intermediate range of comorbidities ²⁶	Binary variable=1 if the patient has 2 or 4 comorbidities and HCV, and 0 otherwise
Diabetes	Binary variable=1 if the patient has medical exemption/Charlson index related to diabetes, and 0 otherwise
HIV Infection	Binary variable=1 if the patient has medical exemption/Charlson index for HIV, and 0 otherwise
Cardiac	Binary variable=1 if the patient has medical exemption/Charlson index related to cardiac diseases, and 0 otherwise
Circulatory System	Binary variable=1 if the patient has medical exemption/Charlson index related to circulatory System diseases, and 0 otherwise
Respiratory	Binary variable=1 if the patient has medical exemption/Charlson index related to respiratory diseases, and 0 otherwise
Liver	Binary variable=1 if the patient has medical exemption/Charlson index related to liver diseases, and 0 otherwise
Kidney	Binary variable=1 if the patient has medical exemption/Charlson index related to kidney diseases, and 0 otherwise
Neoplastic	Binary variable=1 if the patient has medical exemption/Charlson index related to neoplastic diseases, and 0 otherwise
Rheumatic	Binary variable=1 if the patient has medical exemption/Charlson index related to rheumatic diseases, and 0 otherwise
Psychiatric	Binary variable=1 if the patient has medical exemption/Charlson index related to psychiatric diseases, and 0 otherwise
Neurological	Binary variable=1 if the patient has medical exemption/Charlson index related to neurological diseases, and 0 otherwise
Hypercholesterolemia	Binary variable=1 if the patient has medical exemption/ Charlson index related to hypercholesterolemia disease, and 0 otherwise
Hypertension	Binary variable=1 if the patient has medical exemption/Charlson index related to hypertension disease, and 0 otherwise
Gastroenterology	Binary variable=1 if the patient has medical exemption/Charlson index related to gastroenterological disease, and 0 otherwise
Other	Binary variable=1 if the patient has medical exemption/Charlson index related to some other disease, and 0 otherwise

5.4 Heterogeneity analysis and robustness checks

As robustness checks, we run the two regression models, slightly changing the endogenous dependent variable to re-estimate the effect after refining our dependent variable. First, we restrict entitlement to disability benefits to those who were already entitled before 2015. In this way, we aim to isolate the effects of people entitled to benefits before the introduction of DAAs (which allows complete recovery in 95% of the cases). We expect that they will lose more because they already rely on economic benefits.

²⁶ This variable is a proxy for the probability of having a high score of disability; the intermediate range includes people who are at higher risk of losing disability incentives in case of recovery from HCV.

Second, we consider as “entitled to disability benefits” only those with a 100% disability level, but without the attendance allowance. It can be argued that despite rules establishing that in the presence of an attendance allowance, a person may no longer be entitled to benefits after a periodic check, the ones with attendance allowance hardly lose the benefit. Thus, we do not consider them in our definition of entitlement.

We conduct heterogeneity analysis by applying the proposed model to specific population subgroups split by age group, exemption due to income combined with entitlement to benefits before 2015, and the number of comorbidities (see *Tables A.5, A.6, and A.7* of Appendix *A.3 Heterogeneity Analysis*, respectively). Hence, patients with a severely compromised health status (and therefore, a high number of comorbidities) may have a lower risk of losing disability benefits, even in cases of recovery from HCV. In contrast, those with an intermediate group of chronic conditions (two to four) may be at a higher risk of losing the 100% disability score (and therefore, entitlement to economic benefits) if they recover from HCV. Given this consideration, particular focus is placed on those with an intermediate number of comorbidities.

6. Results and discussion

6.1 Descriptive statistics

Table 2 presents the descriptive statistics comparing the demographic, socioeconomic, and health status characteristics of untreated/treated patients and patients entitled to disability benefits. Overall, of the 8.365 patients affected by HCV in Liguria, 4.953 received DAA therapy, while 3.412 (41%) did not receive any treatment. Among patients entitled to disability benefits, the percentage of untreated patients is dramatically higher (58%). This percentage accounts for 36% of the individuals not entitled to disability benefits ($p < 0.05$). The percentage of untreated individuals would be even higher (approximately 60%) if we limited our consideration to those entitled to disability benefits before 2015 (when DAA were introduced in Italy). Additionally, almost 48% of patients exempted due to income or unemployment are untreated. Interestingly, the percentage of untreated individuals reaches 66% if we consider individuals with poor economic situations (i.e., exemption due to income or unemployment) and who were entitled to disability before 2015. Grouping patients by chronic conditions, we notice that for some patients (those with cardiac, circulatory, respiratory, kidney, neoplastic, neurological, rheumatic, and neurological diseases), the proportion of untreated patients exceeds 60%.

People entitled to disability benefits account for 19.6% of the population. As expected, there is a significant overlap between having a chronic condition and being entitled to disability benefits. For

certain medical conditions (such as cardiac, kidney, psychiatric, and neurological diseases), the proportion of individuals entitled to disability benefits is relatively high.

Table 2: Outcome variables split by socio-demographic and health status characteristics

Group variable	Variables	Total (no.)	Untreated (%)	Entitled to disability benefits (%)
<i>Outcome</i>	Untreated	3412	-	28%
	Entitled to disability benefits	1638	58,4%	-
	Entitled to disability benefits before 2015	1064	59,4%	-
	Entitled to disability benefits (without attendance allowance)	990	53,5%	-
<i>Demographic and socioeconomic characteristics</i>	Over 65	2892	51,7%	24,5%
	Male	4910	39,3%	18,1%
	Death	1385	82,7%	42,3%
	Italian citizen	8063	40,6%	20%
	Exemption due to income or unemployment	3762	47,8%	24,6%
	Substance abuse	414	35,5%	20,5%
<i>Health status characteristics</i>	Intermediate comorbidity range (2–4 +HCV)	2366	58,7%	37,6%
	Diabetes	1063	55%	35,6%
	HIV	633	33,7%	35,9%
	Cardiac	504	74,4%	44,8%
	Circulatory system	137	72,3%	32,8%
	Respiratory	566	62,7%	36,6%
	Liver	1743	51,4%	33,2%
	Kidney	525	69,5%	47,2%
	Neoplastic	2019	64,5%	30,9%
	Rheumatic	94	63,8%	38,3%
	Psychiatric	33	39,4%	45,5%
	Neurological	955	72%	43,8%
	Hypercholesterolemia	70	52,9%	31,4%
	Hypertension	865	54,3%	30,2%
	Gastroenterological	145	58,6%	33,1%
Other	230	56,5%	33,5%	

6.2 Recursive bivariate model results

Tables 3 and 4 show the results of the recursive bivariate probit model. As mentioned previously, Models 1 and 2 differ in their IV specifications. *Tables 3 and 4* report the marginal effects of the structural equation (i.e., dependent variable = being untreated) and reduced form (i.e., dependent variable = being entitled to disability benefits). Regarding the reduced-form results, both models highlight that the instruments chosen are good predictors of entitlement to disability benefits. The validity and strength of the instruments are tested using the approach fully described in *Section 5.2.2* and the results are all consistent in confirming the validity of the instruments. In Model 1 (*Table 3*), an additional chronic condition increases the likelihood of being entitled to

disability by about 9%; through the results of Model 2, it is possible to obtain detailed information about which disease mostly influences the determination of entitlement to disability benefits: as we can see from *Table 4*, the presence (beyond HCV) of neurological and psychiatric diseases increases the probability of entitlement to disability benefits by 17%; presence of HIV or kidney, rheumatic, or neoplastic diseases increase the likelihood of entitlement in a range of 12%–14%, while the presence of others such as cardiac, circulatory system, respiratory, liver, and gastroenterological diseases, as well as diabetes, increase this likelihood by approximately 5%–8%. As discussed in *Section 2.2*, the Italian welfare system is highly structured and articulated, and the attribution of disability score is not a linear function of the number of diseases, so it is not possible to estimate *a priori* the association between a disability score and the presence of a specific disease. The final entitlement to disability benefits is contingent upon a clinical evaluation of a single patient and their health status compromise; in any case, the higher the number and severity of diseases, the higher the probability of being entitled to disability benefits.

Other factors that positively influence the probability of entitlement to disability benefits are the presence of exemption due to income or unemployment and having a pre-2015 HCV diagnosis.

Table 3: Results from Recursive Bivariate Probit_Baseline model 1_Marginal effect.

Variables	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	Untreated
Entitled to disability benefits		0.408*** (0.015)
Exemption due to income or unemployment	0.025*** (0.009)	0.022** (0.01)
Male	-0.041*** (0.008)	0.014 (0.009)
Age group: 15–44		
Age group: 45–64	0.006 (0.013)	-0.082*** (0.013)
Age group: over 65	-0.022 (0.015)	0.055*** (0.015)
Diagnosed before 2015	0.024*** (0.009)	0.325*** (0.01)
Substance abuse	0.040** (0.019)	-0.025 (0.02)
Sum_disease	0.092*** (0.003)	
N° observations		8,365
Athrho		-0.736 (0.055)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Results from Recursive Bivariate Probit Baseline Model 2.

Variables	Reduced form Entitled to disability	Structural No treatment
Entitled to disability benefits		0.426*** (0.013)
Exemption due to income or unemployment	0.029*** (0.009)	0.021** (0.009)
Male	-0.040*** (0.008)	0.014 (0.009)
Age group: 15–44 (reference)		
Age group: 45–64	0.005 (0.013)	-0.082*** (0.013)
Age group: over 65	-0.019 (0.015)	0.052*** (0.015)
Diagnosed before 2015	0.016* (0.009)	0.316*** (0.01)
Substance abuse	0.040** (0.019)	-0.025 (0.02)
Diabetes	0.062*** (0.01)	
HIV	0.123*** (0.013)	
Cardiac	0.086*** (0.015)	
Circulatory system	0.069*** (0.025)	
Respiratory	0.071*** (0.013)	
Liver	0.070*** (0.009)	
Kidney	0.126*** (0.014)	
Neoplastic	0.137*** (0.008)	
Rheumatic	0.126*** (0.031)	
Psychiatric	0.175*** (0.049)	
Neurological	0.175*** (0.01)	
Hypercholesterolemia	0.038 (0.037)	
Hypertension	0.008 (0.012)	
Gastroenterological	0.053** (0.026)	
Other	0.028 (0.02)	
N° observations		8,365
Athrho		-0.847 (0.057)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Regarding the structural equation, the results show that entitlement to disability benefits has a positive and statistically significant effect on the probability of not receiving the treatment (in Model 1, the marginal effect is almost 41%, while in Model 2, it is about 43%) and the presence

of exemption due to income increases the probability of remaining untreated by about 2%. As underlined in *Section 2*, there is a lack of literature related to this matter. Studies on disability incentives are mainly focused on work recovery or participation in the workforce (Chen and van der Klaauw, 2008; French and Song, 2014; Koning et al., 2022; Maestas et al., 2013).

The presence of a pre-2015 HCV diagnosis also increases the probability of not undergoing treatment in both models (with a marginal effect of approximately 30%), suggesting that patients who already have an HCV diagnosis (and perhaps were already entitled to disability benefits) are less likely to receive treatment and recover from the disease given the risk of losing economic aid. These individuals may have lived with the (silent) HCV infection for several years and continue to consider it an incurable disease. In contrast, those who received the diagnosis after the discovery of the cure are more inclined to choose treatment, because they do not know how their condition may evolve in the medium or long term.

These results are in line with some cognitive biases; patients affected by chronic conditions are in a state of uncertainty and sometimes have to make relevant decisions in an emotionally charged state (Mazzocco et al., 2019; Savioni and Triberti, 2020; Szekely and Miu, 2015). They might end up choosing suboptimal treatment (such as pre-DAA drugs) or even none, just because they perceive it as less risky but fail to consider the advantages (Fraenkel et al., 2012; Pravettoni et al., 2016). This might be the case for patients already entitled to disability benefits who have lived for decades with a silent HCV and perceive it to be less risky to remain in an illness trap instead of recovering from an invalidating disease, just because they overestimate the economic but not health benefits.

Regarding demographic aspects, in both models, middle-aged individuals (45–64 years) have a lower probability of not receiving treatment than younger individuals (15–44 years). In contrast, those over 65 years of age are more likely to remain untreated than younger individuals. This result aligns with those of extant literature, highlighting the correlation between age and adherence to therapy (Uchmanowicz et al., 2018), particularly in the presence of multiple comorbidities and related therapies (Kim et al., 2019; Smaje et al., 2018).

The correlation parameter ρ between patients' treatment status and entitlement to disability benefits determines whether and how unobservable factors jointly affect the outcome variables (no treatment). ρ tests the independence of the two equations. Therefore, if the parameter is significantly different from 0, we may assume that the two outcome variables in the model are not independent, supporting the hypothesis that the recursive bivariate model is the correct

approach. The results show a statistically significant negative correlation between the disturbances of the proposed equations, which means that unobservable factors that decrease the probability of being entitled to disability benefits increase the likelihood of not receiving treatment (Brugiavini et al., 2022; Di Novi et al., 2023). For example, patients with a severe health status, such as metastatic carcinoma, may have a low disability score (maybe due to the absence of time to conduct administrative steps to submit a request for a revision of the disability score), but the damage to several of their organs may induce clinicians to avoid further treatment since their health is irreversibly compromised.

6.3 Heterogeneity

We performed heterogeneity analysis by running the model for different groups separately (patients with and without exemption due to income, patients under 65 and those over 65, and patients with a different range of comorbidities) to explore the impact of being entitled to disability benefits on the decision not to receive treatment in each group. In *Tables A.5, A.6, and A.7 of Appendix A.3*, we provide the detailed marginal effects for each model specification. In *Table 5* we report the marginal effects for the baseline model (presented in detail in *Tables 3 and 4*) and for the heterogeneity check models.

Table 5: Results from Recursive Bivariate Probit Baseline Model 2.

	<i>Baseline model</i>	Exemption due to income or unemployment		Age Class		Comorbidity range (a)	
		<i>Yes</i>	<i>No</i>	<65	65+	2-4	<2 or >4
Entitled to disability benefits	0.408***	0.529**	0.319***	0.256***	0.528***	0.500***	0.451***

(a) This heterogeneity check has been developed using the second specification (Model 2)

The marginal effect of the Model 1 baseline is approximately 41%. In the first heterogeneity check, we consider the impact of being entitled to disability benefits before 2015 on the choice to undergo treatment by splitting the sample according to the presence or absence of exemption due to income or unemployment. As shown in *Table 5*, the impact of being entitled to disability benefits on the probability of not being treated is significantly higher for people with an exemption due to income or unemployment than for those without it (53% vs. 32%). Since people with such exemption are likely to be more vulnerable from a socioeconomic perspective, these results corroborate our intuition of a possible distorting effect on disability benefits with respect to the therapeutic choices of vulnerable individuals. Indeed, despite the wide literature

on the positive correlation between income level and adherence to drug therapy for different diseases (Ji and Hong, 2020; Teppo et al., 2022), little is known about the impact of income level on the choice to receive treatment for potentially curable diseases. A previous study on HIV (i.e., Galárraga et al., 2013), a disease similar to HCV in community relevance and social reach, revealed that economic incentives may trigger adherence to therapy.

Regarding age groups, the impact of being entitled to benefits on the probability of being untreated is stronger among older individuals (over 65 years) (53% vs. 26%), consistent with extant literature (Kim et al., 2019; Smaje et al., 2018; Uchmanowicz et al., 2018) and our baseline model results.

Concerning the heterogeneity analysis related to a critical range of comorbidities (2–4 plus HCV), we use Model 2 with disease dummies as instruments. The marginal effect of the Model 2 baseline is 43%. The results in *Table 5* show that the number of comorbidities has different effects on the decision not to receive treatment, conditional on being entitled to disability benefits. This heterogeneity check is particularly useful, given the complex system of disability benefits. Indeed, patients with chronic active hepatitis (with no other chronic conditions) may have a disability level of 51 %, making them unlikely to be entitled to disability allowances. In contrast, people with several comorbidities in addition to HCV may have a lower risk of losing disability benefits in the case of recovery from HCV because they are likely to have a disability level over 100%. Those with a disability percentage very close to 100% (e.g., having HCV and two other comorbidities) may be more likely to lose the allowance in the case of recovery from HCV. Therefore, we consider those having a “critical” number of comorbidities (2–4 plus HCV) as an interesting group of individuals. Our results confirm that disability benefits have a more significant impact on the decision not to receive treatment for people with a critical number of comorbidities (50% vs. 45%) and that the effect for those in the critical comorbidities range is higher than the effects for the whole population.

6.4 Robustness checks

We run Models 1 and 2 again as robustness checks, slightly changing the variable measuring entitlement to disability benefits in two different ways (for more detail, see *Section 5.4*). First, we consider entitlement to disability benefits only for those who were already entitled to disability benefits before the introduction of DAAs in Italy (i.e., before 2015). With this small change, we can isolate the effect to those who perhaps already benefited from disability benefits

and faced a tangible risk of economic loss in the case of recovery from HCV. The results for Models 1 and 2 are presented in *Tables 6* and *7*.

Table 6: Results from Recursive Bivariate Probit Model 1 Entitlement to disability benefits before 2015

Variables	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	No treatment
Entitled to disability benefits before 2015		0.427*** -0.021
Exemption due to income or unemployment	-0.003 (0.008)	0.042*** (0.01)
Male	-0.035*** (0.007)	0.015 (0.009)
Age group: 15–44 (ref)		
Age group: 45–64	0.011 (0.011)	-0.079*** (0.014)
Age group: over 65	0.001 (0.013)	0.066*** (0.016)
Diagnosed before 2015	0.048*** (0.008)	0.333*** (0.011)
Substance abuse	0.017 (0.017)	-0.019 (0.021)
Sum_disease	0.060*** (0.002)	
N° observations		8,365
Athrho		-0.738 (0.063)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 7: Results from Recursive Bivariate Probit Model 2 Entitlement to disability benefits before 2015

Variables	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	No treatment
Entitled to disability benefits before 2015		0.443*** (0.02)
Exemption due to income or unemployment	-0.002 (0.008)	0.041*** (0.01)
Male	-0.035*** (0.007)	0.014 (0.009)
Age group: 15–44		
Age group: 45–64	0.01 (0.011)	-0.079*** (0.014)
Age group: over 65	0.008 (0.013)	0.064*** (0.016)
Diagnosed before 2015	0.043*** (0.008)	0.328*** (0.011)
Substance abuse	0.012 (0.017)	-0.02 (0.021)
Diabetes	0.052*** (0.009)	
HIV	0.099*** (0.011)	
Cardiac	0.059*** (0.013)	
Circulatory system	0.045** (0.023)	
Respiratory	0.059*** (0.011)	
Liver	0.043*** (0.008)	
Kidney	0.080*** (0.012)	
Neoplastic	0.080*** (0.008)	
Rheumatic	0.065** (0.028)	
Psychiatric	0.120*** (0.041)	
Neurological	0.114*** (0.009)	
Hypercholesterolemia	0.023 (0.032)	
Hypertension	-0.003 (0.011)	
Gastroenterological	0.041* (0.022)	
Other	0.019 (0.017)	
N° observations		8,365
Athrho		-0.814 (0.065)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Evidently, the marginal effects of being entitled to disability benefits before 2015 are positive and statistically significant in both models (43% and 44 %, respectively) and slightly greater (1% point) than in the baseline models. The other results are consistent with those of the baseline models.

To further test the baseline models, we consider only those entitled to disability benefits and have total (100%) disability but without an attendance allowance, since it may be argued that those with an attendance allowance are at a relatively low risk of losing economic benefits (given their severe health status with or without HCV). We test whether our baseline model results are still consistent. *Tables 8 and 9* present the results for Models 1 and 2, respectively. As shown, entitlement to disability benefits (excluding the presence of attendance allowance) entails a higher probability of being untreated in both models (41% and 42%, respectively), consistent with the baseline models. Moreover, the results for the other variables are consistent with those of the baseline models.

Table 8: Results from Recursive Bivariate Probit Model 1 Entitlement to disability benefits excluding attendance allowance

Variables	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	No treatment
Entitled to disability benefits (excluding attendance)		0.409*** (0.021)
Exemption due to income or unemployment	-0.005 (0.008)	0.043*** (0.01)
Male	-0.022*** (0.007)	0.009 (0.009)
Age group: 15–44		
Age group: 45–64	0.01 (0.011)	-0.079*** (0.014)
Age group: over 65	-0.011 (0.012)	0.072*** (0.016)
Diagnosed before 2015	-0.003 (0.008)	0.361*** (0.01)
Substance abuse	0.01 (0.016)	-0.014 (0.021)
Sum_disease	0.061*** (0.002)	
N° observations		8,365
Athrho		-0.731 (0.061)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 9: Results from Recursive Bivariate Probit_Model 2 Entitlement to disability benefits excluding attendance allowance

Variables	<i>Reduced form</i>		<i>Structural equation</i>	
	Entitled to disability benefits	to disability	No treatment	
Entitled to disability benefits (excluding attendance)			0.423***	(0.02)
Exemption due to income or unemployment	0		0.043***	(0.01)
Male	-0.023***		0.009	(0.009)
Age group: 15–44				
Age group: 45–64	0.005		-0.079***	(0.014)
Age group: over 65	-0.009		0.070***	(0.016)
Diagnosed before 2015	-0.012		0.357***	(0.01)
Substance abuse	0.016		-0.013	(0.021)
Diabetes	0.035***			
HIV	0.099***			
Cardiac	0.045***			
Circulatory system	0.060***			
Respiratory	0.043***			
Liver	0.052***			
Kidney	0.097***			
Neoplastic	0.120***			
Rheumatic	0.082***			
Psychiatric	0.069			
Neurological	0.077***			
Hypercholesterolemia	0.029			
Hypertension	0.014			
Gastroenterological	0.038*			
Other	-0.012			
N° observations			8,365	
Athrho			-0.807	(0.063)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

7. Conclusions

The welfare state protects citizens against risks, such as unemployment, disability, and healthcare expenditure. Extant literature on disability allowances focuses on their effects on resuming work or participating in the labor market. However, generous monetary benefits may also have perverse effects by reducing the incentives to receive treatment for invalidating ailments, which, in the long run, may become even more pervasive than the negative effects of poverty and disability traps. Despite its relevance, this illness trap has not received much attention in literature. Results can not easily related to the previous findings, since, to the best of our knowledge, this study is the first one covering a gap in the literature related to the effect of disability benefits on the treatment uptake. Yet, a patient who decides to remain ill so as to not lose economic benefits represents social defeat.

In this study, we test this hypothesis by analyzing the interesting case of the introduction of a new (potentially curative) treatment for HCV. Despite massive screening campaigns, a large percentage of individuals remain untreated worldwide. Our results show that patients entitled to disability benefits are more likely not to receive the curative new HCV treatment, which we interpret as an “illness trap:” although recovering from HCV is possible, the patient chooses not to use anti-HCV drugs to avoid losing economic benefits.

This effect is amplified for people belonging to the lowest income brackets (signaled by the presence of exemption due to income or unemployment). Furthermore, being entitled to disability benefits before the introduction of new DAAs (2015), incentivizes patients to not receive treatment, since they might have already accepted to live with the disease (which perhaps has been silent for decades). That is, they may be less inclined to lose the benefits; the strategy behind this choice is affected by some cognitive biases, and it is vital to intervene in it.

From a policy perspective, policymakers should consider this disincentive when setting disability allowances and eligibility criteria. Health must be a priority and related interventions should stress the importance of recovery, supporting patients with no opportunity to survive unless they choose to stay ill so as to not lose their disease-related economic benefits.

In Italy, where individual eligibility requirements are monitored periodically to confirm, increase, or decrease the disability level, the medical commission can be asked to discuss with the patient the options of treatment for HCV and eventually reduce the disability points to individuals who refuse treatment without any specific medical reason. This simple and relatively inexpensive approach could significantly reduce the number of illness traps.

In this study, it is not possible to match each patient with their general practitioner (GP), but the role of GPs in patients' decisions is well documented in the literature. From a policy perspective, it would also be important to incentivize GPs to make patients more prone to accept HCV treatment.

The case examined here extends beyond the Italian context. Most Western countries use grants to subsidize the income of seriously ill or disabled individuals. Therefore, the growing availability of potentially curative treatments for chronic pathologies must be considered in the setting of welfare state instruments aimed at patients. As shown by the results of this study, the possibility of losing a monetary subsidy after receiving curative treatment represents a possible incentive to reject the treatment, with harmful and unexpected consequences for the individual and the community.

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Contributions

All the authors have read and approved the final version of the manuscript. **Marta Giachello:** Data curation, Software, Formal analysis, Writing - Original Draft **Lucia Leporatti:** Conceptualization, Methodology, Formal analysis, Writing - Original Draft **Rosella Levaggi:** Conceptualization, Validation, Writing - Original Draft **Marcello Montefiori:** Conceptualization, Validation, Writing - Original Draft

Availability of data and materials

The datasets that support the findings of this study are available from Regione Liguria; however, restrictions apply as these data were used under license for the current study and are not publicly available.

Ethics declarations

The study, based on routine administrative information, was carried out in compliance with A.Li.Sa (Azienda Sanitaria Regione Liguria) data processing regulations and the Italian Data Protection Act. Administrative data were anonymized prior to the analysis at the regional statistical office, where each patient is assigned a unique identifier. This identifier does not allow to trace the patient's identity and other sensitive information. Given the characteristics of the study, using anonymized administrative data, no ethical approval was needed

Competing interests

The authors declare that they have no competing interests

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9. Appendix

Appendix A.1

Below we report, as an example, the Table with disability score range for each disease related to digestive system. There is a specific table for each system. For detail see Ministerial Decree 5th February 1992.

Table A.1: Digestive Systems Diseases with related range of disability score

	cod.		min	max	fixed
DIGESTIVE SYSTEM					
3	8201	PRETERNATURAL ANUS ILIAC LEFT	0	0	41
3	6428	OPERATED ESOPHAGEAL ATRESIA (II CLASS)	21	30	0
3	6429	OPERATED ESOPHAGEAL ATRESIA (III CLASS)	41	50	0
3	6408	GALLSTONE WITHOUT COMPROMISE OF GENERAL HEALTH	0	0	21
3	6411	LIVER CIRRHOSIS WITH PERSONALITY DISORDERS (INTERMITTENT H	0	0	95
3	6412	LIVER CIRRHOSIS WITH PORTAL HYPERTENSION	71	80	0
3	6417	CHOLECYSTO-DUODENOSTOMY - OUTCOMES	0	0	9
3	6418	ULCERATIVE COLITIS (III CLASS)	41	50	0
3	6419	ULCERATIVE COLITIS (IV CLASS)	61	70	0
3	6420	COLON DIVERTICULOSIS (II CLASS)	21	30	0
3	6421	COLON DIVERTICULOSIS (III CLASS)	41	50	0
3	6101	HEMORRHOIDS	0	0	10
3	6424	CHRONIC ACTIVE HEPATITIS	0	0	51
3	6425	AUTOIMMUNE CHRONIC ACTIVE HEPATITIS	0	0	70
3	6426	CHRONIC ACTIVE HEPATITIS OF CHILDHOOD	71	80	0

3	6427	OPERATED CONGENITAL DIAPHRAGMATIC HERNIA	1	10	0
3	8205	CERVICAL ESOPHAGOSTOMY AND GASTROSTOMY	0	0	80
3	6432	ANAL-RECTAL FISTULA	0	0	10
3	6433	GASTRO-DUODENO-COLIC FISTULA (II CLASS)	21	30	0
3	6434	GASTRO-DUODENO-COLIC FISTULA (III CLASS)	41	50	0
3	6435	GASTRO-DUODENO-COLIC FISTULA (IV CLASS)	61	70	0
3	6436	GASTROENTEROSTOMY - FUNCTIONAL NEOSTOMA (II CLASS)	21	30	0
3	6437	GASTROENTEROSTOMY - FUNCTIONAL NEOSTOMA (III CLASS)	0	0	41
3	6452	RIGHT HEPATIC LOBECTOMY	0	0	35
3	8203	MEGACOLON - COLOSTOMY (II CLASS)	21	30	0
3	8204	MEGACOLON - COLOSTOMY (III CLASS)	41	50	0
3	6458	CROHN'S DISEASE (I CLASS)	0	0	15
3	6459	CROHN'S DISEASE (II CLASS)	21	30	0
3	6460	CROHN'S DISEASE (III CLASS)	41	50	0
3	6461	CROHN'S DISEASE (IV CLASS)	61	70	0
3	6464	CHRONIC PANCREATITIS (I CLASS)	0	0	10
3	6465	CHRONIC PANCREATITIS (II CLASS)	21	30	0
3	6466	CHRONIC PANCREATITIS (III CLASS)	41	50	0
3	6467	CHRONIC PANCREATITIS (IV CLASS)	61	70	0
3	6471	RECTAL PROLAPSE	0	0	8
3	6472	RECTAL PROLAPSE	0	0	5
3	6484	POSTPRANDIAL SYNDROME FROM GASTRECTOMY (I CLASS)	0	0	10

3	6485	POSTPRANDIAL SYNDROME FROM GASTRECTOMY (II CLASS)	11	20	0
3	9333	ENTEROGENIC MALABSORPTION SYNDROME WITH COMPROMISED GENER	41	50	0
3	6454	GASTRIC OR DUODENAL ULCER (II CLASS)	0	0	10
3	6455	GASTRIC OR DUODENAL ULCER (III CLASS)	21	30	0

Source: Ministerial Decree 5th February 1992

Appendix A.2

Table A.2 shows the ICD-9-CM diagnostic codes used to identify patients with HCV infection during hospitalizations or accesses to emergency rooms.

Table A.3 and Table A.4 show the ATC (Anatomical Therapeutic Chemical, a system of chemical substances classification) considered as drugs for treating HCV, split between drugs used before the availability of DAA drugs (mentioned as Pre) and DAA (mentioned as Post).

Table A.2: Diagnostic code (ICD-9-CM) for HCV. Source: International Classification of Diseases, 9th revision- Clinical Modification (ICD-9-CM), (Ministero della Salute, 2007).

Code	Description
070.41	Acute Hepatitis C with hepatic coma
070.44	Chronic Hepatitis C with hepatic coma
070.51	Acute Hepatitis C without mention of hepatic coma
070.54	Chronic Hepatitis C without mention of hepatic coma
070.70	Unspecified viral Hepatitis C without hepatic coma
070.71	Unspecified viral Hepatitis C with hepatic coma

Table A.3: List of HCV drugs “PRE”

Therapeutic Subgroup	Chemical Substance	ATC code
Interferons	Interferon Alfa-2A	L03AB04
	Interferon Alfa-2B	L03AB05
Pegylated interferons	Peginterferon Alfa-2B	L03AB10
	Peginterferon Alfa-2A	L03AB11
Ribavirin	Ribavirin	J05AP01; J05AB04
Protease inhibitors (1 st gen.)	Telaprevir	J05AP02; J05AE11
	Boceprevir	J05AP03; J05AE12

Source: our elaboration from AIFA data (Aifa, 2022)

Table A.4: List of HCV drugs “POST”

Therapeutic Subgroup	Chemical Substance	ATC Codes	
Polymerase Inhibitors	Sofosbuvir	J05AP08	J05AX15
	Dasabuvir	J05AP09	
Protease inhibitor (2nd gen.)	Simeprevir	J05AP05	J05AE14
	Glecaprevir		
	Grazoprevir	J05AP11	
	Paritaprevir		
	Faldaprevir	J05AP04	
Inhibitors NS5A	Asunaprevir	J05AP06	J05AE15
	Daclatasvir	J05AP07	J05AX14
	Ledipasvir		

Inhibitors of viral protein synthesis	Elbasvir	J05AP10	
	Ombitasvir		
	Pibrentasvir		
	Velpatasvir		
Inhibitor	Sofosbuvir + Ledipasvir	J05AP51	J05AX65
	Paritaprevir + Ritonavir + Ombitasvir	J05AP53	J05AX67
	Dasabuvir+Paritaprevir + Ritonavir + Ombitasvir	J05AP52	J05AX66
	Elbasvir + Grazoprevir	J05AP54	J05AX68
	Sofosbuvir+ Velpatasvir	J05AP55	J05AX69
	Sofosbuvir + Velpatasvir+Voxilaprevir	J05AP56	
	Glecaprevir + Pibrentasvir	J05AP57	
	Daclatasvir + Asunaprevir + Beclabuvir	J05AP58	

Source: elaboration from data (Aifa, 2022)

Appendix A.3

In this section are presented all recursive bivariate probit model results related to heterogeneity analysis (form more details refers to *section 5.4*).

Table A.5: Results from Recursive Bivariate Probit_Robustness Disability ante 2015 with and without exemption due to income or unemployment_Marginal effect

Variables	With Exemption due to income or unemployment		Without Exemption due to income or unemployment	
	<i>Reduced form</i>	<i>Structural equation</i>	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	to No treatment	Entitled to disability benefits	No treatment
Entitled to disability benefits before 2015		0.529*** (0.022)		0.319*** (0.033)
Male	-0.047*** (0.012)	0.035** (0.014)	-0.025*** (0.009)	0 (0.012)
Age group: 15–44				
Age group: 45–64	0.01 (0.023)	-0.066*** (0.025)	0.007 (0.012)	-0.079*** (0.016)
Age group: over 65	0.011 (0.023)	0.094*** (0.025)	-0.014 (0.015)	0.024 (0.021)
Diagnosed before 2015	0.062*** (0.012)	0.245*** (0.017)	0.035*** (0.01)	0.389*** (0.012)
Substance abuse	0.009 (0.027)	-0.036 (0.03)	0.019 (0.021)	0.026 (0.029)
Sum_disease	0.056*** (0.003)		0.066*** (0.003)	
N° observations		3,762		4,603
Athrho		-1.093 (0.112)		-0.506 (0.076)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.610: Results from Recursive Bivariate Probit_under and over 65_Marginal effect

Variables	People under 65		People over 65	
	<i>Reduced form</i>	<i>Structural equation</i>	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	to No treatment	Entitled to disability benefits	No treatment
Entitled to disability benefits		0.256*** (0.026)		0.528*** (0.013)
Exemption due to income or unemployment	0.019* (0.01)	0.005 (0.012)	0.031* (0.018)	0.058*** (0.016)
Male	-0.004 (0.01)	-0.022* (0.012)	-0.110*** (0.015)	0.081*** (0.014)
Diagnosed before 2015	0.020** (0.01)	0.374*** (0.011)	0.046*** (0.017)	0.249*** (0.018)
Substance abuse	0.042** (0.017)	0.009 (0.021)	-1.667 (18522)	-0.15 (0.217)
Sum_disease	0.102*** (0.004)		0.085*** (0.004)	
N° observations	5,473		2,892	
Athrho		-0.396 (0.061)		-1.217 (0.115)

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.7: Results from Recursive Bivariate Probit_Disability ante 2015 and intermediate comorbidity range (2-4 chronic conditions +HCV)_Marginal effect

Variables	Critic level of comorbidity* (2-4+ HCV)		No critic level (<2 or >4)	
	<i>Reduced form</i>	<i>Structural equation</i>	<i>Reduced form</i>	<i>Structural equation</i>
	Entitled to disability benefits	to No treatment	Entitled to disability benefits	to No treatment
Entitled to disability benefits <u>before 2015</u>		0.500*** (0.019)		0.451*** (0.028)
Exemption due to income or unemployment	-0.042** (0.019)	0.047*** (0.018)	0.013* (0.008)	0.017 (0.011)
Male	-0.081*** (0.018)	0.048*** (0.017)	-0.016** (0.007)	-0.001 (0.01)
Age group: 15–44				
Age group: 45–64	-0.027 (0.042)	0.016 (0.038)	0.01 (0.01)	-0.095*** (0.014)
Age group: over 65	-0.052 (0.045)	0.170*** (0.04)	0.012 (0.011)	0.001 (0.017)
Diagnosed before 2015	0.119*** (0.018)	0.093*** (0.022)	0.019** (0.008)	0.381*** (0.01)
Substance abuse	0.063 (0.044)	-0.038 (0.043)	-0.006 (0.016)	-0.006 (0.022)
Diabetes	0.071*** (0.017)		-0.018 (0.015)	
HIV	0.074*** (0.025)		0.073*** (0.012)	
Cardiac	0.091*** (0.021)		0.005 (0.02)	
Circulatory system	0.038 (0.038)		0.056* (0.03)	
Respiratory	0.064*** (0.02)		0.056*** (0.015)	
Liver	0.024 (0.017)		0.028*** (0.01)	
Kidney	0.085*** (0.021)		0.077*** (0.018)	
Neoplastic	0.056*** (0.017)		0.081*** (0.009)	
Rheumatic	0.086* (0.045)		0.008 (0.046)	
Psychiatric	0.101 (0.072)		0.079 (0.051)	
Neurological	0.130*** (0.017)		0.105*** (0.013)	
Hypercholesterolemia	-0.028 (0.054)		0.028 (0.044)	
Hypertension	-0.019 (0.019)		-0.011 (0.016)	
Gastroenterological	0.04 (0.038)		0.028 (0.031)	
Other	0.004 (0.03)		0.024 (0.022)	
N° observations	2,366		5,999	
Athrho	-1.434 (0.244)		-0.867 (0.09)	

Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$