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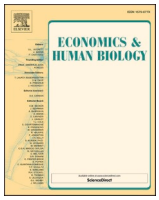

Labour market implications of thyroid dysfunctions

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ABSTRACT

This paper aims to shed some light on the labour market implications of thyroid disease. Undetected hypothyroidism has adverse effects on wages for female workers,thus widening the existing gender wage gap. However, once female individuals are diagnosed (and therefore assumed to be treated) with hypothyroidism, they experience wage gains and have a higher employment probability. In relation to other labour market outcomes, thyroid disease does not appear to play a significant role on individuals' labour force participation decision and their working hours. Results suggest that productivity gains may drive the improvement in wages.

1. Introduction

This study examines the effects of thyroid dysfunctions, both hypothyroidism and hyperthyroidism, on labour market outcomes, such as wages, employment probability, labour force participation, and working hours, and explores whether there are gender disparities in the estimated effects. To our knowledge, this is the first paper that addresses the labour market implications of thyroid diseases. This research is important for public health, as it suggests that identifying (and treating) thyroid dysfunctions, particularly hypothyroidism, in their early stages could result in significant productivity gains.

Studies in the literature have highlighted the impact that chronic diseases have on various labour market outcomes for people living with these conditions (OECD/EU, 2016). Individuals suffering from health disorders such as diabetes (Rumball-Smith et al., 2014), cancer (Heinesen and Kolodziejczyk, 2013) and musculoskeletal diseases (Oxford Economics, 2010) are estimated to have reduced employment prospects. Evidence also suggests that chronic diseases impact on working hours and influence the choice between full-time and part-time employment (Pelkowski and Berger, 2004). People with diabetes are found to work fewer hours, to be more likely to choose a part-time job (Saliba et al., 2007), and have higher rates of absenteeism (Tunceli et al., 2005). Similar evidence is found for people suffering from cancer (Moran et al., 2011; Drolet et al., 2005) and musculoskeletal diseases (Office for National Statistics, 2014). In addition, chronic diseases are associated with labour productivity losses, reflected in lower levels of wages (Pelkowski and Berger, 2004). For example, diabetic people on average are found to earn less than non-diabetic workers (Minor, 2013). Importantly, the literature also suggests that these conditions affect women more than men (Saliba et al., 2007), thus amplifying existing gender inequalities in the labour market.

Among chronic diseases, thyroid dysfunctions are very common and can have serious implications for the physical, mental and emotional life of those affected, with potentially severe consequences for their ability to participate in social and work life. Thyroid patients have been found to be at greater risk of long-term sick leave and impairment of working ability (for a recent survey see Leso et al., 2020), to be significantly more likely to be on sickness absence, disability pension, and unemployment (Nexo et al., 2014). Using a sample from a Danish Register-Based Cohort Study over a 17 years period, Thvilum et al. (2014) found a diagnosis of hypothyroidism in working age population to be associated with a significantly lower increase in income labour[1] and an 89% increased risk of receiving a disability pension. These results are confirmed by Brand et al. (2015) who studied the effects of hyperthyroidism on disability pension and labour income using a random sample from the Danish Twin Registry.[2] Evidence on how thyroid diseases affect labour market outcomes, however, remains rather limited.

To our knowledge, this is the first paper that focusses on the effects of thyroid diseases on labour market outcomes – thus contributing to address an important gap in the literature. Our research questions are

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[1] Hypothyroid individuals had on average a €1605 smaller increase in income than the control from 2 years before to 2 years after the diagnosis of the disease.

[2] Ponto et al. (2013) found patients affected by Graves' Orbitopathy to have impaired earning capacity and to suffer from considerable direct and indirect costs.

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informed by a number of important stylized facts that emerge from the medical literature on thyroid dysfunctions. First, they are much more common in women than in men (e.g.: Bauer et al., 2014; Castello and Caputo, 2019; Taylor et al., 2018; Vanderpump, 2011). Second, although thyroid disease can take many forms, hypothyroidism is the most prevalent, and especially so in women (Taylor et al., 2018), where it is potentially 10 times more common than in men (Vanderpump, 2011). Third, subclinical hypothyroidism is a very commonly detected abnormality (e.g. Bauer et al., 2014; Biondi et al., 2019) which is normally not treated.[3] Fourth, undiagnosed thyroid disorder (particularly subclinical hypothyroidism) is frequent (Canaris et al., 2000; Mendes et al., 2019) as many thyroid disease symptoms can mimic other conditions; this is particularly true for women with hypothyroidism, with an associated higher risk of misdiagnosis (Castello and Caputo, 2019). Fifth, in women symptoms tend to persist longer and are less effectively managed by therapy (Castello and Caputo, 2019).

In light of these stylized facts, we ask whether thyroid disease, and in particular hypothyroidism, can contribute to explain female/men differences in key labour market outcomes and whether diagnosis (and hence, presumably, the start of treatment) can have a positive impact on such outcomes. To examine these issues, we employ data from the UK Household Longitudinal Survey (UKHLS) (2009–2018). The UKHLS contains information on a number of health conditions, including thyroid disease (hyperthyroidism and hypothyroidism). Specifically, individuals are asked to report whether they have ever been diagnosed or newly diagnosed with thyroid conditions. This enables us to compare individuals before and after they have been diagnosed (and thus presumably treated) with thyroid dysfunction, and also compare them against people who will not be diagnosed with thyroid problems (at least during the sample period).

Our results suggest that undetected hypothyroidism has adverse effects on wages for female workers. However, once female individuals are diagnosed (and therefore assumed to be treated) with hypothyroidism, they experience wage gains and improve their employment probability. In relation to other labour market outcomes, thyroid disease does not appear to play a significant role on individuals' labour force participation decisions and their working hours. Given that analysis of the raw data shows that individuals do not change jobs, get promoted or change grades once diagnosed with thyroid issues, we conjecture that the estimated wage effects might be driven by productivity gains. Comparison of people who receive performance-related-pay (PRP) or bonus payments with people who do not have such remuneration packages suggests that this might indeed be the case.

Our study makes three important contributions to the existing literature. First, it investigates the implications on thyroid dysfunctions on labour market outcomes, such as wages, labour force participation, employment probability and working hours. By considering a wider range of labour market outcomes than what has hitherto been considered in the literature, the paper enables a better understanding of how thyroid disease may impact individuals' level of engagement in the labour market. Second, it explores the effect of both types of thyroid dysfunctions, hypothyroidism and hyperthyroidism. Although both are associated with similar magnitudes of increased morbidity and mortality (Thvilum et al., 2014), we know relatively little on whether these conditions have a similar impact on individuals' work lives. Third, last but not least, this paper investigates whether there are gender disparities in the impact that thyroid dysfunctions have on labour market outcomes. In showing that such differences have the potential to amplify existing gender inequalities in the labour market, the paper makes therefore an important contribution to the long-established literature on the issue of gender wage gap and its determinants (for reviews, see Altonji et al., 1999; Blau and Kahn, 2000 and 2017; Weichselbaumer and Winter-Ebmer, 2005). Gender differences in earnings have been a persistent phenomenon in the UK labour market and, although there has been progress in bridging the pay gap over the last century, gender disparities in wage still remain sizeable (Olsen et al., 2018; Costa Dias et al., 2020). A key defining factor for the narrowing of the gender pay gap has been the growing gender convergence in productivity-related characteristics. As a result, the portion of the gender differentials in earnings that may be explained by such observable differences has also declined (Blau and Kahn, 2006, 2016; Manning and Swaffield, 2008; Goldin, 2014; Kassenboehmer and Sinning, 2014). In light of this, recent studies have focused on other observable factors such as gender differences in preferences and psychological attributes (Niederle and Vesterlund, 2007; Manning and Saidi, 2010; Ifcher and Zarghamee, 2016; Reuben et al., 2017; Wiswall and Zafar, 2017; Schäfer and Schwiebert, 2018); the gender composition of managerial staff (Abendroth et al., 2017; Quintana-Garcia and Elvira, 2017; Bryson et al., 2022); the segregation of women into less profitable firms (Rycx and Tojerow, 2004); and the role of the public sector (Jones et al., 2018). Our results provide evidence of an additional pathway that may lead to greater gender pay inequality. Thyroid dysfunction can easily be identified. If left undiagnosed, however, it can have a serious negative impact on the health and life of those concerned. Our analysis has important implications for public health, as it suggests that productivity gains can potentially be achieved through the early detection (and treatment) of thyroid dysfunction, in particular of hypothyroidism.

The remaining of the paper is structured as follows. In Section 2 we explain the epidemiology of thyroid diseases and in Section 3 we discuss the data and the empirical strategy. The results are presented in Section 4. Section 5 concludes the paper.

2. The epidemiology of thyroid diseases

Thyroid dysfunctions affect the working of the thyroid gland. The primary hormone produced by the thyroid gland is thyroxine (T4) which, once delivered to the body's tissues via the bloodstream, is converted into triiodothyronine (T3). The hormone production function of the thyroid is regulated via a feedback effect that involves the brain via the production of the thyrotropin-releasing hormone (TRH), which stimulates the release of the thyroid stimulating hormone (TSH) by the pituitary gland.

The two main types of thyroid disorders are hypothyroidism (underactive thyroid) and hyperthyroidism (overactive thyroid). These may or may not be associated with a goitre (enlargement of the thyroid gland), thyroid nodules (lumps or abnormal masses within the thyroid gland), and thyroid cancer. Hypothyroidism can be caused by iodine deficiency, autoimmune disorders (Hashimoto's thyroiditis), thyroid hormones resistance, or inflammation of the thyroid. Hyperthyroidism can be caused by Graves' disease, inflammation of the thyroid, or by tumours.

Diagnosis, alongside an assessment of the symptoms, is typically based on blood tests that measure the levels of TSH, thyroid hormones, the presence of anti-thyroid antibodies as well as ultrasound scans to the thyroid gland. In the case of hypothyroidism, treatment typically involves integration of the thyroid hormones with synthetic ones. Hyperthyroidism can be treated pharmacologically to reduce the levels of

[3] In a systematic review of the literature, Mendes et al. (2019) conclude that in Europe there is large proportion of subclinical hypothyroidism which is undiagnosed. On the other hand, Taylor et al. (2014) provide evidence that subclinical hypothyroidism is increasingly treated in primary care. In a retrospective cohort study based on data from the UK Clinical Practice Research Datalink, their findings suggest that the benefits from a widespread treatment prescribing for borderline TSH levels are limited. Overtreatment for borderline hypothyroidism is also found for the UK by Brito et al. (2021). There is also evidence that up to a third of patients maintained normal levels of thyroid blood test after treatment was discontinued, particularly for those with an initial diagnosis of subclinical hypothyroidism (Burgos et al., 2021).

hormones, or via radioactive ablation to selectively destroy the thyroid tissue. In some cases, surgery is required to remove nodules or the thyroid gland itself. Following removal of the thyroid, synthetic hormones are administered.

The thyroid produces hormones that play a critical role in regulating several metabolic processes throughout the body. A malfunctioning of the thyroid gland can have a significant impact on the wellbeing of the affected individuals. The nature of the symptoms depends on the type of thyroid disease. An overproduction of thyroid hormone (hyperthyroidism) increases body metabolism and may result in loss of weight, unusual nervousness, restlessness and anxiety, and inability to tolerate high temperatures. At moderate levels of hyperthyroidism, people may have a lot of energy but, if the problem persists, tiredness becomes common. In contrast, having an underactive thyroid can decrease or slow down bodily functions. In this case, people often feel more tired, gain weight, feel depressed and may be more sensitive to cold temperatures.

In most cases, appropriate therapy significantly reduces the symptoms of the condition. If left untreated, or if not appropriately treated, however, thyroid dysfunction can lead to severe health problems. Untreated hypothyroidism can result in infertility, birth defects, the insurgence of heart diseases and heart failure, depression and peripheral neuropathy (damage to peripheral nerves). Untreated hyperthyroidism can lead to life-threatening cardiac complications such as atrial fibrillation and stroke, brittle bones, and eye complications among others.[4]

Subclinical thyroid disease is defined by levels of TSH which fall outside the normal range and are associated with levels of thyroid hormones (T4 and T3) which are within the laboratory reference ranges. Evidence suggests that a possible association exists between untreated subclinical thyroid disease and mortality (e.g.: Cooper and Biondi, 2012; Grossman et al., 2016; Razvi et al., 2008, 2010, 2012; Kvetny et al., 2004).

Thyroid dysfunctions are very common and present throughout the world. Overt hyperthyroidism is more prevalent in iodine deficient areas. Where there are sufficient levels of iodine, its prevalence of ranges between 0.2% and 1.3% (Taylor et al., 2018). The great majority of cases of primary hypothyroidism can be accounted for by iodine deficiency and autoimmune diseases (Hashimoto thyroiditis). The prevalence of hypothyroidism in the general population ranges between 0.2% and 5.3% and between 0.3% and 3.7% in Europe and the US respectively (Taylor et al., 2018; Canaris et al., 2000). According to a recent review of UK national databases, the prevalence of treated hypothyroidism in the total UK population was estimated to be 3.5% in 2014, up from 2.3% in 2005 (Razvi et. al, 2019), with a rate of over 5% for those aged over 60 (NICE, 2019). Hyperthyroidism is estimated to have a prevalence of 0.5–2% among women in the UK. Studies have reported a prevalence of subclinical hypothyroidism in the UK that ranges between 4% and 20% (Okosieme et al., 2016; NICE, 2019) Subclinical hyperthyroidism is estimated to affect up to 10% of the population (NICE, 2019; Franklyn and Boelaert, 2012). As noted earlier, gender disparities in the occurrence of the disease are quite prominent. In the UK, both hypothyroidism and hyperthyroidism are up to 10 times more common in women than in men (Vanderpump, 2011; Ingoe et al., 2017; Mendes et. al, 2019).

3. Data, descriptive statistics, and methodology

We use data from the first eight waves of UKHLS that cover the period 2009–2018. UKHLS is a survey that gathers data on a sample of approximately 40,000 households in England, Scotland, Wales, and Northern Ireland. This is a panel survey that follows all individuals in a household over time, including those who leave or new members who join the household. It began in 2009 and data are collected annually. UKHLS obtains longitudinal data on a broad range of domains, such as health, work, education, income, family and social life. The data are publicly available from the UK Data Service. The sample used in this paper is restricted to female and male individuals aged 18–65.[5] Individuals are asked to report whether they have ever been diagnosed in the past or are newly diagnosed with a number of health conditions, including hyperthyroidism and hypothyroidism. There is a small number of cases where individuals initially report hypothyroidism and later in the sample period experience a switch to hyperthyroidism or vice versa. These cases are excluded from our sample.[6] Table 1 gives the descriptive statistics for our sample from which emerge stylized facts that are broadly consistent with findings reported in the medical literature. First, female individuals have a higher incidence of thyroid dysfunction and this is true for both hyperthyroidism and hypothyroidism. Second, individuals diagnosed with hypothyroidism are three times more than those diagnosed with hyperthyroidism. This holds true for both males and females. Finally, people are typically diagnosed with thyroid dysfunctions in their mid 40s

Table 1
Descriptive Statistics.

	μ (all)	μ_f (female)	μ_m (male)	$H_0 : \mu_f = \mu_m$
Incidence				
Thyroid	0.029	0.045	0.011	***
	(0.169)	(0.207)	(0.103)	
Hyperthyroidism	0.007	0.011	0.003	***
	(0.083)	(0.103)	(0.052)	
Hypothyroidism	0.023	0.035	0.008	***
	(0.149)	(0.184)	(0.089)	
Observations	239,770	132,337	107,443	
Average detection age				
Hyperthyroidism	46.227	46.359	45.622	
	(11.535)	(11.525)	(11.696)	
Hypothyroidism	46.923	46.524	48.587	*
	(11.948)	(12.112)	(11.120)	

μ is the proportion in sample and the numbers in parenthesis are standard deviation. The last column reports the t test for H_0 where ***, ** and * respectively indicate statistical significance level at 1%, 5% and 10%.

Our aim is to explore the impact that thyroid disease has on various labour market outcomes. Specifically, we consider: wages, labour force participation, employment status, and weekly working hours. To do so, we use the panel regression analysis based on the following equation:

$$y_{it} = x'_{it}\gamma + \beta_1 gender_i + \beta_2 Thyroid_{it} + \delta_t + \alpha_i + \varepsilon_{it} \quad (1)$$

The dependent variable y_{it} represents the labour market outcome of interest for individual i at period t; the vector x includes the usual individual demographic characteristic variables (age, marital status,

[4] Lillevang-Johansen et al. (2019) provide evidence that cardiovascular risk is increased in untreated hypothyroidism; the importance of maintaining adequate treatment is also highlighted, as both over and under-treatment had similar negative impact on cardiovascular risk (Lillevang-Johansen et al., 2019) and on excess mortality (Lillevang-Johansen et al., 2018).

[5] The sample excludes full-time students and those on maternity leave, long-term sick leave or disabled, government training scheme, unpaid family business, apprenticeship, or armed forces.

[6] There are 19 individuals (100 observations) who changed from hyperthyroidism to hypothyroidism and 26 individuals (97 observations) who did the opposite.

education, other health conditions and co-morbidities,[7][8]) and, when applicable, work-related characteristic variables (controlling for full-time job, permanent contract, private sector, occupation, industry), and location which is captured by regional dummy variables. $gender_i$ is a gender dummy which takes the value of one if individual i is female and zero otherwise, hence β_1 captures the 'adjusted' gender wage gap[9] and its estimates are found in the literature to be negative and statistically significant. $Thyroid_{it}$ is a dummy which takes the value of one for individual i when affected by thyroid disease and zero otherwise. Furthermore, because thyroid disease is more prevalent amongst women, we shall also augment (1) with an interaction term, $gender_i \bullet Thyroid_{it}$, as an additional explanatory variable which enables us to check whether the impact of the disease is gender-specific. δ_t is the time fixed effect, α_i captures unobserved heterogeneity amongst the individuals, and ε_{it} represent the idiosyncratic disturbances. All equations are estimated using random effects. This approach is preferred to the fixed effects alternative since there is low within-group variation in the key explanatory variable of interest, the thyroid variable. Specifically, once an individual is diagnosed with a thyroid dysfunction, her thyroid status does not change for the rest of the sample period. Hence, for every individual in the sample, there is only one possible change in their thyroid condition variable.

Thyroid dysfunctions, in contrast to other chronic health conditions are less likely to be the outcome of lifestyle behaviour, hence, we treat the development and diagnosis of thyroid diseases as exogenous. Lifestyle behaviours, however, may still have an indirect effect by influencing other chronic conditions which subsequently may increase the risk of thyroid diseases. In addition, it may also be possible that individual heterogeneity may affect the diagnosis of the condition. For example, people with specific risk attitudes and preferences may visit their GP more frequently and thus have a higher likelihood of being diagnosed with a thyroid dysfunction if present. Part of the estimation strategy relies on comparing individuals before and after they are diagnosed with a thyroid disease. This means that such potential unobserved heterogeneity between individuals, in terms of lifestyle behaviours or preferences, should not have any significant impact, as they would likely affect both time periods equally. Hence, we are confident in our estimation strategy, where thyroid dysfunctions are treated as exogenous, and the reliability of the estimates.

We shall use three alternative definitions of thyroid disease: one where we make no distinction on the type of thyroid dysfunction, and two where we identify whether it is a case of hyperthyroidism or hypothyroidism. In addition, utilizing the relevant sample, we make the three different comparisons that follow.

(I) **"Before" vs "Never"** – Comparison between:

1. Individuals who at the time of the interview have not yet been diagnosed (including the period prior to 2009, when the survey started), but who will be diagnosed at one of the later survey waves, and
2. Individuals who have not been diagnosed (including the period prior to 2009, when the survey started) and will not be diagnosed with thyroid disease throughout the sample period.

(I) **"After" vs "Never"** – Comparison between:

1. Individuals who have already been diagnosed with thyroid disease (either prior to 2009, or at some point up the interview date of the corresponding wave), and
2. Individuals who will not be diagnosed with thyroid disease at any point during the sample period.

(I) **"After" vs "Before"** – Comparison between

1. Individuals who have already been diagnosed with thyroid disease, and
2. Individuals who will be diagnosed later during the sample period.

For example, consider an individual who has not been diagnosed with a thyroid dysfunction up until 2010 and is diagnosed with a condition in 2011. For the first two years of the survey (2009 and 2010) she will be considered in the "before" group, and for all subsequent years she will be included in the "after" group. Similarly, someone who has been diagnosed with a thyroid condition at some point before the start of the UKHLS survey will be considered in the "after" group for all waves of UKHLS.

Our overall sample consists of 58,126 individuals, out of which 55,631 individuals (230,549 observations) have not been diagnosed with a thyroid dysfunction either before or at any point during the years of survey ("never" group). In addition, there are 655 individuals (2162 observations) who have not yet been diagnosed but will be diagnosed with a thyroid dysfunction at some point during the survey years ("before" group), and 1840 individuals (7061 observations) who have been diagnosed with a thyroid dysfunction either before or during the survey years ("after" group).

4. Results

In this section we report the thyroid and gender related coefficients for the following labour market outcomes: wages, labour force participation, employment status, and weekly working hours.[10] The tables presenting the results are divided into three panels. The top panel, labeled (I) "Before vs Never", explores the effect of undetected thyroid problems on labour market outcomes. If we assume that those diagnosed with thyroid dysfunction are given the appropriate treatment, then panels (II) and (III) – respectively labeled "After vs Never" and "After vs Before" – show how detection of thyroid diseases affect individuals' labour market outcomes. As discussed in the previous section, we employ three different definitions of thyroid disease. In columns (1) and (2) we do not make a distinction between hyperthyroidism or hypothyroidism. In columns (3) and (4) we focus only on hyperthyroidism (thus excluding individuals with hypothyroidism), while in columns (5) and (6) we consider hypothyroidism only (thus excluding individuals with hyperthyroidism).

4.1. Wage effects

The results presented in Table 2 reflect the effects of thyroid disease

[7] All estimated equations include binary controls for 15 other health conditions, including: asthma, arthritis, congestive heart failure, coronary heart disease, angina, heart attack or myocardial infarction, stroke, emphysema, chronic bronchitis, any kind of liver condition, cancer or malignancy, diabetes, epilepsy, high blood pressure, and clinical depression.

[8] We also explored two additional specifications. First, we included a mental health score variable based on the 12-item General Health Questionnaire, GHQ-12, that ranges from 0 (the least distressed) to 36 (the most distressed). Second, we estimated a model where, instead of 15 individual controls for health condition, we included a Physical Component Summary (PCS) and a Mental Component Summary (MCS), calculated based on the Short-Form 12 Health Survey questions. The results remain robust to all specifications explored. The results are available from the authors on request.

[9] The regression analysis provides an 'adjusted' measure of the wage gap between male and female workers since we control for differences in their observable individual and workplace characteristics. This is different from measurements of gender wage gap that rely on raw data comparisons and hence are unadjusted.

[10] The rest of the coefficient estimates are not reported but are available from the authors on request.

Table 2
Wages.

	Thyroid		Hyperthyroidism		Hypothyroidism	
(I) Before vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.133 ***	-0.132 ***	-0.131 ***	-0.131 ***	-0.133 ***	-0.132 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Thyroid	-0.037 **	0.029	-0.048	-0.020	-0.036 *	0.031
	(0.017)	(0.038)	(0.036)	(0.101)	(0.020)	(0.037)
Female x Thyroid	–	-0.082 *	–	-0.084	–	-0.085 **
		(0.043)		(0.107)		(0.043)
Number of obs.	143,501	143,501	145,547	145,547	144,144	144,144
(II) After vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.132 ***	-0.132 ***	-0.132 ***	-0.132 ***	-0.132 ***	-0.132 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Thyroid	0.004	0.002	-0.031	-0.033	0.015	0.013
	(0.013)	(0.025)	(0.035)	(0.052)	(0.013)	(0.029)
Female x Thyroid	–	0.003	–	0.003	–	0.002
		(0.029)		(0.066)		(0.032)
Number of obs.	146,145	146,145	143,146	143,146	145,225	145,225
(III) After vs Before	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.150 ***	-0.203 ***	-0.172 *	-0.227 **	-0.129 ***	-0.181 ***
	(0.031)	(0.039)	(0.086)	(0.102)	(0.033)	(0.040)
Thyroid	0.039 **	-0.018	0.028	-0.035	0.042 **	-0.013
	(0.016)	(0.026)	(0.033)	(0.068)	(0.018)	(0.028)
Female x Thyroid	–	0.070 **	–	0.077	–	0.069 **
		(0.030)		(0.072)		(0.033)
Sample Size	5239	5239	1273	1273	3966	3966

The dependent variable is the logarithm of hourly wages and the estimation method is random-effects. The numbers in parentheses are standard errors clustered by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by *** , ** and * , respectively. The sample consists of those employed (excluding self-employed individuals).

on wages, where the logarithm of hourly wages is the dependent variable.

We begin the analysis with the "Before" versus "Never" comparison, in order to identify the effects of yet undiagnosed thyroid diseases. Starting from panel (I), estimates in column (1) show that, as expected, there is an 'adjusted' gender wage gap of about 13%. In addition, all those who have not yet been diagnosed with a thyroid dysfunction but will be at some point in the future seem to have 3.7% lower wages compared to those who will not be diagnosed with a thyroid problem at any point during the sample period. In column (2) we explore whether there are gender differences in the effect of undetected thyroid dysfunctions by adding the interaction term. The results reveal that the negative wage differential effect of thyroid disease is gender-specific and is driven by female workers. No wage differences are found when comparing male individuals with undetected thyroid dysfunctions with male workers that do not have a thyroid condition, but there is a significant wage penalty for female individuals with undetected thyroid dysfunctions. According to our estimates, therefore, the adjusted gender wage gap for the female individuals with undetected thyroid conditions is larger, as they receive 5.3% lower wages than comparable female individuals with no thyroid dysfunctions; the interaction effect is statistically significant at 10% and its inclusion renders the general thyroid effect insignificant. In the following columns we report the results based on restricting the sample to include only those with hyperthyroidism – columns (3) and (4) – or hypothyroidism – columns (5) and (6). Results suggest that the impact of thyroid dysfunctions is driven by female workers who will be diagnosed with hypothyroidism: whilst there is no significant effect in columns (3) and (4), columns (5) and (6) show that female workers who will be diagnosed with hypothyroidism receive 5.4% lower wages than comparable female individuals with no thyroid dysfunction; the interaction effect is now statistically significant at 5% and, as in column (2), its inclusion renders the general thyroid effect insignificant. This finding is in line with the literature on other chronic diseases which are also found to affect women more severely than men (Saliba et al., 2007), thus increasing existing gender labour market inequalities.

It is worth remarking at this point that thyroid diseases are often associated with other health conditions, both physical and mental. Hence, their effects may be mediated through related comorbidities. One such potential pathway is individuals' psychological wellbeing as both the overproduction and underproduction of thyroid hormones can lead to mood disorders and, in some cases, depression.[11] In order to assess whether the estimated effects, presented in panel (I) of Table 2, are driven by thyroid diseases or whether they reflect the effect of other associated health conditions, we re-estimate the model, where we gradually introduce control variables for other comorbidities and examine the robustness of our estimates. Specifically, we explore four alternative specifications and present the estimates in Table A1 in the Appendix: Model (1) does not include controls for any other health conditions apart from thyroid diseases; Model (2) introduces controls for 14 other comorbidities, excluding clinical depression; Model (3) augments Model (2) by including a control for clinical depression (this is the specification also used in Table 2); finally, Model (4) is the same as Model (1) with the addition of a Physical Component Summary (PCS) and a Mental Component Summary (MCS) that are calculated based on the Short-Form 12 Health Survey questions. The results remain remarkably robust across all specifications considered, clearly suggesting that thyroid diseases have a direct effect on wages, over and beyond that of other health conditions and related comorbidities.

In order to benchmark and evaluate how important the negative consequences of undiagnosed thyroid disease are vis-à-vis other health conditions, we also consider the effect on wages of three other chronic conditions. Specifically, we estimate the impact of, yet undiagnosed, clinical depression, high blood pressure and diabetes, whilst including thyroid diseases among the other comorbidities we control for. The estimates are provided in Table A2 in the Appendix. The results suggest a wage penalty of around 4%, which is slightly lower than the effect of undiagnosed hypothyroidism reported in panel (I) of Table 2. Furthermore, similar gender disparities are revealed, at least in the case of high blood pressure and diabetes, where the estimated adverse effects seem to be driven by female individuals only. This comparison between thyroid

[11] There is evidence that points to patients with thyroid disorders being more likely to develop depression symptoms (Hage and Azar, 2012; Bode et al., 2022).

Table 3
Timing of diagnosis and wages.

		Thyroid		Hyperthyroidism		Hypothyroidism	
	Wage Shift	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Pre-diagnosis Period	θ_5	-0.151 ***	-0.071	-0.219 ***	0.163	-0.109 ***	-0.056
		(0.032)	(0.053)	(0.071)	(0.223)	(0.036)	(0.058)
	θ_4	-0.124 ***	0.085	-0.156 ***	0.155	-0.108 ***	0.105
		(0.028)	(0.074)	(0.059)	(0.173)	(0.032)	(0.088)
	θ_3	-0.122 ***	0.006	-0.105 *	0.191	-0.127 ***	-0.013
		(0.034)	(0.052)	(0.058)	(0.240)	(0.039)	(0.037)
	θ_2	-0.072 ***	0.032	-0.088 *	0.118	-0.068 **	0.037
		(0.024)	(0.047)	(0.053)	(0.291)	(0.027)	(0.045)
	θ_1	-0.056 **	0.006	-0.080 *	0.088	-0.036	-0.017
		(0.023)	(0.048)	(0.044)	(0.106)	(0.028)	(0.054)
Post-diagnosis Period	δ_1	0.056 **	0.012	0.048	0.124	0.052 *	-0.003
		(0.026)	(0.037)	(0.056)	(0.109)	(0.029)	(0.039)
	δ_2	0.043	0.090 **	0.030	0.121	0.056 *	0.063 *
		(0.028)	(0.036)	(0.051)	(0.104)	(0.029)	(0.037)
	δ_3	0.076 **	0.072	0.036	0.322 **	0.095 ***	0.041
		(0.030)	(0.058)	(0.062)	(0.131)	(0.036)	(0.065)
	δ_4	0.113 ***	0.069	0.122	0.118	0.119 ***	0.044
		(0.032)	(0.077)	(0.080)	(0.164)	(0.036)	(0.066)
	δ_5	0.224 ***	0.165	0.189 *	0.115	0.248 ***	-0.013
		(0.058)	(0.125)	(0.112)	(0.237)	(0.065)	(0.130)
	Sample Size	1995	514	530	119	1465	395

The dependent variable is the logarithm of hourly wages and the estimation method is random-effects. The numbers in parentheses are standard errors clustered by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by *** , ** and * , respectively. The sample consists of those employed (excluding self-employed individuals) who are diagnosed with thyroid disease during the sample period.

diseases and other health conditions emphasizes the severity of undiagnosed hypothyroidism and the importance of early diagnosis. Importantly, by underlining that the adverse labour market effects of thyroid diseases are comparable to, if not larger than, those of other chronic conditions, this study contributes to fill an important gap in the literature which has hitherto overlooked this relationship.

Our results so far highlight another potential contributing factor to gender pay inequality. Therefore, it is important to assess whether the detection of thyroid disease may help reduce such gender wage disparities. Hence, we now consider the "After" versus "Never" comparison, where we compare those who have been diagnosed with those who are not diagnosed with a thyroid dysfunction over the sample period. The results are reported in panel (II) of Table 2. As the estimates in columns (1) and (2) show, after diagnosis, where we assume treatment begins, the thyroid-specific wage penalty seem to disappear: there is no wage difference between those who have been diagnosed with a thyroid condition and those who do not experience a thyroid dysfunction during the sample period; columns (3) to (6) show that this result holds for both types of the disease. To the extent that diagnosis might be immediately followed by treatment, this result suggests that discovering and dealing with the thyroid dysfunction eliminates the previous negative impact of the undiagnosed disease on wage differentials. Therefore, post-diagnosis there may productivity gains associated with the treatment workers possibly receive.

Finally, to further check the importance of diagnosis, we do the "After" versus "Before" comparison, where we compare those individuals who have already been diagnosed with the disease with those who have not yet been diagnosed but will be at some point during the sample period. Thus, the sample is considerably smaller since it only includes those individuals who at any given time either already have or will later develop the disease during the sample period. The results are reported in panel (III) of Table 2 and suggest that post-diagnosis individuals earn higher wages, confirming the importance of diagnosis. This effect is entirely driven by female employees. The estimates in column (1) of this panel show that post-diagnosis individuals receive wages higher by 3.9%. Column (2) shows that this effect is entirely driven by female employees: when allowing for the interaction between gender and thyroid disease, wages increase by 5.2% post-diagnosis, suggesting that females individuals recover the wages losses incurred when the thyroid dysfunction was undetected. Furthermore, it is only those women with hypothyroidism who experience an increase in wages once the condition is diagnosed.

As discussed in Section 3, concerns about the exogeneity of the development and diagnosis of thyroid dysfunctions do not arise when comparing individuals over two periods of time. Specifically, in the estimates presented in panel (III) of the table, we compare individuals before and after diagnosis, so any unobserved individual heterogeneity should not matter, as it is expected to equally affect both periods of time.

We re-estimated the wage equations separately for male and female workers and found the results based on gender-stratified samples to be fully consistent with those based on the full sample reported in Table 2.[12] Results clearly suggest that untreated hypothyroidism has an adverse effect on female workers' wages which is eliminated once hypothyroidism is diagnosed (and therefore presumably treated): there is no wage difference between those who have thyroid disease and those who are not been and will not be diagnosed with thyroid disease (of either type). Hence, whilst hyperthyroidism does not appear to have an impact on wages in general, and those female workers who are diagnosed with (and presumably treated for) hypothyroidism seem to recover the wage loss they previously experienced.

The issue of identifying and separating the effect on labour market outcomes of the diagnosis of a chronic disease from its treatment is an important one (Rizzo et al., 1996). However, the UKHLS dataset only reports the diagnosis of a thyroid dysfunction and not whether an individual receives some medication or treatment once diagnosed. Thus, our estimate of wage improvement for women, once hypothyroidism is diagnosed, should be interpreted as a lower bound estimate since it is possible that not all those diagnosed with thyroid conditions in the sample have received treatment. The estimated wage effect could be larger if all those who were diagnosed had also received treatment.

The estimates in Table 2 suggest that on average female individuals with undetected hypothyroidism experience a 5.4% wage penalty, compared to their female peers that do not have thyroid problems. However, this wage penalty disappears after diagnosis, and presumably

[12] These results are not included in the paper, but are available upon request from the authors.

Table 4
Labour Force Participation.

	Thyroid		Hyperthyroidism		Hypothyroidism	
(I) Before vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.154 ***	-0.154 ***	-0.155 ***	-0.155 ***	-0.154 ***	-0.154 ***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Thyroid	-0.005	-0.009	-0.034	-0.001	-0.002	-0.016
	(0.014)	(0.019)	(0.026)	(0.034)	(0.016)	(0.024)
Female x Thyroid		-0.004		-0.042		0.022
		(0.025)		(0.046)		(0.030)
Obs	232709	232709	236565	236565	233845	233845
(II) After vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.155 ***	-0.154 ***	-0.154 ***	-0.154 ***	-0.154 ***	-0.154 ***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Thyroid	-0.014 *	0.006	-0.027	-0.008	-0.010	0.012
	(0.009)	(0.015)	(0.016)	(0.025)	(0.010)	(0.018)
Female x Thyroid		-0.025		-0.022		-0.026
		(0.018)		(0.031)		(0.021)
Obs	237608	237608	232178	232178	235977	235977
(III) After vs Before	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.168 ***	-0.160 ***	-0.186 ***	-0.199 ***	-0.164 ***	-0.146 ***
	(0.016)	(0.021)	(0.032)	(0.039)	(0.019)	(0.025)
Thyroid	0.003	0.011	0.016	-1.932e-4	-0.004	0.014
	(0.011)	(0.016)	(0.020)	(0.026)	(0.014)	(0.019)
Female x Thyroid		0.010		0.020		-0.024
		(0.018)		(0.031)		(0.023)
Obs	9316	9316	2275	2275	7041	7041

The dependent variable is labour force participation and estimates are based on random-effects linear probability model. The numbers in parenthesis are standard errors cluster by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by *** , ** and * , respectively.

with the start of treatment. These estimates do not tell us though how the wage profile evolves over time, in relation to when diagnosis takes place. To explore this, we estimate the following wage equation

$$y_{it} = x'_{it}\gamma + \sum_{b=1}^{5} \theta_b T_{i0-b} + \sum_{a=1}^{5} \delta_a T_{i0+a} + \delta_t + \alpha_i + \varepsilon_{it} \quad (2)$$

The sample is stratified by gender and only includes those individuals who at some point during the sample period were diagnosed with thyroid dysfunction. T_{i0} is the period in the sample at which individual i is diagnosed and T_{i0-b} and T_{i0+a} are dummies which are set to unity b periods before and a periods after T_{i0} and zero otherwise.[13] The estimates of θ_b and δ_a are reported in Table 3 and pick up the shift in wage that occurs over time b periods before and a periods after diagnosis respectively.

The results in Table 3 confirm our pervious finding that female individuals are adversely affected by undetected thyroid dysfunctions, but experience wage gains after diagnosis, specifically in the case of hypothyroidism. In addition, Table 3 reveals that the effects of undetected thyroid dysfunctions are evident even five years before diagnosis, with the estimate of θ_5 in the case of female hypothyroidism suggesting a wage penalty of around 10%. Also, looking at the period after diagnosis, there is a gradual improvement of wages, with the magnitude of the estimated wage gains exceeding 10% from years four onwards after the time of diagnosis.

Two key points emerge from the analysis of Table 3. First, the findings highlight the importance of being tested for thyroid dysfunctions, as early detection of the condition may help prevent or recover associated wage losses sooner. Second, the potential wage gains may in fact be larger than the (about) 5% suggested by the estimates in Table 2, which is an average estimate for the post-diagnosis period. Since in the sample more people are observed one or two years after diagnosis, the estimated average effect is weighted more towards these first couple of years, when the wage gains are relatively smaller (around 5%), than later when the gains are notably larger in magnitude (over 10%).

4.2. Other labour market outcomes

In this section, we explore whether thyroid dysfunctions affect other labour market outcomes. Specifically, we re-estimate the regressions in Table 2 replacing the dependent variable with the individuals' labour force participation, employment status, and working hours.

For the labour force participation model, we use a binary outcome variable that takes the value of one for economically active individuals (employed, self-employed or unemployed) and zero otherwise (retired or not seeking employment). Table 4 below reports the estimates based on random effect linear probability models which suggest that neither undetected nor diagnosed thyroid disease affect labour force participation. This is true for both individuals with hyperthyroidism and hypothyroidism.[14]

Next, we focus on the workforce, i.e. exclude from the sample those who are economically inactive, and examine how individuals' employment status is affected by thyroid diseases. The dependent variable therefore is a categorical variable which takes value of 1, 2, 3 for self-employed, employed, and unemployed, respectively. Table 5 shows the results, based on multinomial logit models, where each panel is divided into self-employed and unemployed, with the employed being the reference category.

The reported coefficient estimates can be interpreted in terms of a change in the log of the odd of the respective outcome (self-employed or unemployed) relative to the employed which are used as the reference group. Thyroid disease, both pre- and post diagnosis, does appear to affect the likelihood of being either self-employed or employed. In addition, estimates suggest that an undetected thyroid dysfunction increases the multinomial log-odds of being unemployed relative to being employed and there is some evidence that the employment prospects of individuals seem to improve once thyroid disease is diagnosed. This is particularly true for female individuals diagnosed with hypothyroidism.

[13] Note that $b = a = 5$ is the maximum lag or lead. For those who are diagnosed in the early (late) waves of the sample $1 \leq b < 5$ while $1 \leq a \leq 5$ ($1 \leq b \leq 5$ while $1 \leq a < 5$).

[14] The estimates in Table 4 are also confirmed when employing a Logit random effects estimator. Results are available upon request from the authors.

Table 5
Employment outcomes.

	Thyroid		Hyperthyroidism		Hypothyroidism	
(I) Before vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Self-Employed						
Female	-0.806 ***	-0.805 ***	-0.798 ***	-0.797 ***	-0.806 ***	-0.806 ***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Thyroid	-0.098	0.010	-0.086	0.347	-0.049	-0.080
	(0.147)	(0.252)	(0.285)	(0.477)	(0.165)	(0.284)
Female x Thyroid		-0.176		-0.687		0.034
		(0.310)		(0.605)		(0.348)
Unemployed						
Female	-0.392 ***	-0.393 ***	-0.397 ***	-0.395 ***	-0.392 ***	-0.395 ***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Thyroid	0.229 *	0.152	0.545 **	1.089 **	0.104	-0.427
	(0.128)	(0.264)	(0.227)	(0.433)	(0.151)	(0.315)
Female x Thyroid		0.103		-0.767		0.670 *
		(0.301)		(0.508)		(0.358)
Obs	196892	196892	199600	199600	197716	197716
(II) After vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Self-Employed						
Female	-0.802 ***	-0.804 ***	-0.806 ***	-0.805 ***	-0.801 ***	-0.804 ***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Thyroid	0.089	0.034	-0.024	0.190	0.120	-0.021
	(0.093)	(0.183)	(0.206)	(0.402)	(0.102)	(0.201)
Female x Thyroid		0.084		-0.307		0.196
		(0.211)		(0.467)		(0.232)
Unemployed						
Female	-0.398 ***	-0.391 ***	-0.395 ***	-0.392 ***	-0.395 ***	-0.391 ***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Thyroid	0.033	0.330 *	0.098	0.583	0.005	0.224
	(0.087)	(0.183)	(0.181)	(0.407)	(0.097)	(0.189)
Female x Thyroid		-0.398 *		-0.656		-0.292
		(0.206)		(0.447)		(0.219)
Obs	200360	200360	196420	196420	199151	199151
(III) After vs Before	(1)	(2)	(3)	(4)	(5)	(6)
Self-Employed						
Female	-0.771 ***	-0.958 ***	-1.202 ***	-1.489 **	-0.643 ***	-0.759 **
	(0.185)	(0.298)	(0.432)	(0.610)	(0.210)	(0.356)
Thyroid	-0.074	-0.230	-0.090	-0.324	-0.064	-0.160
	(0.166)	(0.270)	(0.364)	(0.524)	(0.188)	(0.326)
Female x Thyroid		0.248		0.411		0.152
		(0.318)		(0.656)		(0.379)
Unemployed						
Female	-0.668 ***	-0.317	-1.225 ***	-1.063 **	-0.438 **	0.274
	(0.180)	(0.303)	(0.340)	(0.493)	(0.199)	(0.361)
Thyroid	-0.358 **	0.016	-0.423	-0.256	-0.218	0.535
	(0.165)	(0.323)	(0.299)	(0.554)	(0.193)	(0.356)
Female x Thyroid		-0.505		-0.264		-0.954 **
		(0.342)		(0.609)		(0.386)
Obs	6894	6894	1694	1694	5200	5200

The dependent variable is employment status. The sample excludes those who are economically inactive, and the employed are used as the reference group. The estimates are based on the multinomial logit model and the numbers in parenthesis are standard errors cluster by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by *** , ** and * , respectively.

To get a sense of the magnitude of the effect, we can compare the corresponding predicted probabilities.[15] According to our estimates, the probability of being unemployed reduces for female individuals by 3% points, from 9% to 6%, after hypothyroidism is diagnosed (and, presumably, treatment commences).

Finally, in Table 6 we assess whether thyroid disease affects individuals' labour supply at the intensive margin where the dependent variable is the logarithm of the number of hours normally worked per week, including overtime paid hours. The estimates are based on random-effects with clustered, by individuals, standard errors.

Overall, the estimates do not suggest important post-diagnosis adjustments in the working hours. Specifically, once diagnosed with hyperthyroidism, male workers slightly adjust their working hours downwards (−1.8 h weekly), compared to their male counterparts who do not have and will not be diagnosed with hyperthyroidism. For female workers, on the other hand, the estimated effects are rather marginal.

4.3. What may be driving the wage gains?

The results so far indicate that once diagnosed with hypothyroidism (and assumed to be subsequently treated), female workers experience a wage increase. When exploring other labour market outcomes (Tables 4–6), the estimates do not suggest that overall the diagnosis of thyroid disease has a notable impact on other labour market outcomes, apart from the improvement of employment prospects, particularly for the female workforce when hypothyroidism is diagnosed. It is therefore important to ask what may be driving the changes in wages.

One logical explanation could be that following diagnosis, individuals previously adversely affected by the disease are able to move to new jobs, gain promotion or change grades. However, after inspecting the raw data in UKHLS, it seems that such changes do not apply to anyone in the sample following diagnosis: the start years of employment

[15] The predicted probabilities are not presented in the paper but are available from the authors on request.

Table 6
Weekly Working Hours.

	Thyroid		Hyperthyroidism		Hypothyroidism	
(I) Before vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-3.959 ***	-3.953 ***	-3.970 ***	-3.969 ***	-3.952 ***	-3.947 ***
	(0.070)	(0.070)	(0.069)	(0.070)	(0.070)	(0.070)
Thyroid	-0.048	0.722	-0.163	0.155	-0.034	0.962
	(0.243)	(0.617)	(0.502)	(1.108)	(0.265)	(0.729)
Female x Thyroid		-0.967		-0.396		-1.162
		(0.669)		(1.242)		(0.779)
Obs	147597	147597	150031	150031	148598	148598
(II) After vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-3.951 ***	-3.956 ***	-3.946 ***	-3.952 ***	-3.959 ***	-3.956 ***
	(0.069)	(0.070)	(0.070)	(0.070)	(0.069)	(0.070)
Thyroid	-0.413 **	-0.631	-0.450	-1.844 ***	-0.400 **	-0.228
	(0.173)	(0.455)	(0.322)	(0.667)	(0.201)	(0.560)
Female x Thyroid		0.265		1.699 **		-0.208
		(0.491)		(0.758)		(0.598)
Obs	150626	150626	147582	147582	149698	149698
(III) After vs Before	(1)	(2)	(3)	(4)	(5)	(6)
Female	-4.104 ***	-4.248 ***	-3.368 ***	-4.257 ***	-4.420 ***	-4.210 ***
	(0.474)	(0.600)	(0.859)	(1.141)	(0.564)	(0.721)
Thyroid	-0.409 *	-0.570	-0.253	-1.321	-0.487 *	-0.263
	(0.240)	(0.514)	(0.459)	(0.918)	(0.285)	(0.641)
Female x Thyroid		0.220		1.304		-0.280
		(0.571)		(1.021)		(0.711)
Obs	5321	5321	1292	1292	4029	4029

The dependent variable is the logarithm of the number of hours normally worked per week (including overtime paid hours) and the sample excludes self-employed individuals. The estimation method is random-effects and the numbers in parenthesis are standard errors cluster by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by *** , ** and * , respectively.

Table 7
Wages (by remuneration type).

	Thyroid		Hyperthyroidism		Hypothyroidism	
(I) Before vs Never	PRP/Bonus	No PRP/Bonus	PRP/Bonus	No PRP/Bonus	PRP/Bonus	No PRP/Bonus
Female	-0.135 ***	-0.112 ***	-0.134 ***	-0.111 ***	-0.134 ***	-0.111 ***
	(0.008)	(0.006)	(0.008)	(0.006)	(0.008)	(0.006)
Thyroid	0.085	-0.073	0.180	-0.182 ***	0.042	-0.037
	(0.074)	(0.060)	(0.241)	(0.056)	(0.056)	(0.073)
Female x Thyroid	-0.104	0.033	-0.104	0.076	-0.094	0.013
	(0.084)	(0.064)	(0.260)	(0.069)	(0.069)	(0.078)
Obs	23311	46096	23589	46831	23401	46336
(II) After vs Never	PRP/Bonus	No PRP/Bonus	PRP/Bonus	No PRP/Bonus	PRP/Bonus	No PRP/Bonus
Female	-0.134 ***	-0.112 ***	-0.134 ***	-0.112 ***	-0.134 ***	-0.111 ***
	(0.008)	(0.006)	(0.008)	(0.006)	(0.008)	(0.006)
Thyroid	-0.023	-0.031	-0.114	-0.050	0.012	-0.026
	(0.041)	(0.031)	(0.073)	(0.053)	(0.048)	(0.037)
Female x Thyroid	0.035	0.066 *	0.117	0.104 *	0.001	0.055
	(0.046)	(0.035)	(0.085)	(0.061)	(0.054)	(0.041)
Obs	23675	47057	23255	46029	23543	46744
(III) After vs Before	PRP/Bonus	No PRP/Bonus	PRP/Bonus	No PRP/Bonus	PRP/Bonus	No PRP/Bonus
Female	-0.190 ***	-0.111 **	-0.213	-0.165 *	-0.219 ***	-0.077
	(0.071)	(0.058)	(0.195)	(0.086)	(0.069)	(0.071)
Thyroid	-0.043	0.015	-0.150	0.080	-0.028	-0.001
	(0.047)	(0.049)	(0.135)	(0.080)	(0.049)	(0.059)
Female x Thyroid	0.098 *	0.083	0.082	0.141	0.105 *	0.052
	(0.053)	(0.051)	(0.166)	(0.091)	(0.053)	(0.061)
Obs	744	1735	180	411	564	1324

See the notes to Table 2. The sample consists of those employed (excluding self-employed individuals).

or change of employment all occur before the year of diagnosis. Hence, it follows that the pay increase observed must occur while they are in same employment. We conjecture, therefore, that the effect of diagnosis/treatment may be on employees' productivity. To verify this conjecture, we explore whether the remuneration structure of contracts matter. Specifically, we make a distinction between workers whose contracts include performance-related-pay (PRP) or bonuses and workers who do not have such contractual elements. Wages in the former case have a variable component that depends on workers' performance and fluctuate accordingly. Hence, to the extent that thyroid dysfunctions affect workers' productivity, this should be reflected in the wages of workers who receive PRP or bonuses. In contrast, when contracts do not have such performance-related elements, wages are expected to remain fairly stable, irrespective to the level of workers' performance and their productivity.

To this end, we re-estimate the wage equations in Table 2 stratifying the sample by remuneration type; however, since information on PRP and bonuses is recorded only every other wave (waves 2, 4, 6, 8), the sample reduces roughly to half the size of the full sample. Results are reported in Table 7. As panel (III) of the table shows, the wage gains observed when comparing individuals who are diagnosed with hypothyroidism with those before they are diagnosed are evident only in the

Table 8
Wages (by occupations: white vs blue collar).

	Thyroid		Hyperthyroidism		Hypothyroidism	
(I) Before vs Never	White collar	Blue Collar	White collar	Blue Collar	White collar	Blue Collar
Female	-0.136 ***	-0.159 ***	-0.135 ***	-0.158 ***	-0.136 ***	-0.159 ***
	(0.005)	(0.010)	(0.005)	(0.010)	(0.005)	(0.010)
Thyroid	0.054	0.035	0.062	-0.019	0.045	0.055
	(0.057)	(0.041)	(0.131)	(0.097)	(0.055)	(0.043)
Female x Thyroid	-0.108 *	-0.084	-0.124	-0.030	-0.100 *	-0.105
	(0.060)	(0.057)	(0.138)	(0.109)	(0.060)	(0.069)
Obs	113096	30405	114957	30590	113663	30481
(II) After vs Never	White collar	Blue Collar	White collar	Blue Collar	White collar	Blue Collar
Female	-0.136 ***	-0.159 ***	-0.136 ***	-0.160 ***	-0.135 ***	-0.159 ***
	(0.005)	(0.010)	(0.005)	(0.010)	(0.005)	(0.010)
Thyroid	-0.025	0.077 *	-0.084	0.098	-0.006	0.071
	(0.032)	(0.041)	(0.062)	(0.087)	(0.036)	(0.046)
Female x Thyroid	0.023	-0.038	0.041	-0.066	0.016	-0.029
	(0.035)	(0.048)	(0.078)	(0.096)	(0.039)	(0.056)
Obs	115482	30663	112835	30311	114695	30530
(III) After vs Before	White collar	Blue Collar	White collar	Blue Collar	White collar	Blue Collar
Female	-0.188 ***	-0.303 ***	-0.189	-0.179	-0.179 ***	-0.254 ***
	(0.049)	(0.062)	(0.120)	(0.189)	(0.050)	(0.078)
Thyroid	-0.027	0.021	-0.022	0.222	-0.027	0.039
	(0.034)	(0.045)	(0.079)	(0.158)	(0.037)	(0.049)
Female x Thyroid	0.064 *	0.088	0.046	-0.136	0.069 *	0.064
	(0.037)	(0.061)	(0.083)	(0.170)	(0.040)	(0.077)
Obs	4524	715	1078	195	3446	520

See notes to Table 2.

case where individuals have a PRP component or bonus element in their remuneration contract. This suggests that the wage gain may be the result of increases in productivity that female individuals with hypothyroidism experience once their condition is diagnosed and, presumably, treated. There is also another interesting finding that was not evident in the initial wage estimates in Table 2. Both male and female individuals in contracts that do not include PRP or bonuses are found to receive lower wages when there is undetected hyperthyroidism, compared to individuals who are not and who will not be diagnosed with hyperthyroidism. This seems to improve once hyperthyroidism is diagnosed. Specifically, there is no wage difference between male workers diagnosed with hyperthyroidism and male workers who are not and will not be diagnosed with hyperthyroidism. For female individuals the wage improvement seems to be larger as, post-diagnosis, they are estimated to receive higher wages than comparable female peers who are not and will not be diagnosed with hyperthyroidism.

These results are important since they shed some light on the underlying mechanism that may drive the estimated wage gains female individuals experience once hypothyroidism is diagnosed. Although individuals are not randomly assigned to PRP contracts or contracts that include bonuses as part of their remuneration structure, thyroid conditions do not seem to affect this choice of contract. Indeed, an analysis of the probability of having a PRP or bonus contract suggests that there are no differences between individuals with undiagnosed or diagnosed thyroid conditions and those with no thyroid problems.[16] Nevertheless, some caution is required when interpreting the results as the estimates may not necessarily reveal causal relationships.

Finally, we explore differences between "white collar" and "blue collar" workers, by stratifying the sample based on occupation. The results are reported in Table 8 and show that female "white collar" workers experience lower wages before the hypothyroidism diagnosis. However, once diagnosed, we see that they experience wage gains and recover such wage losses. Post-diagnosis, there no wage differences persist between "white collar" female workers diagnosed with hypothyroidism and their comparable female peers who are not and will not be diagnosed with hypothyroidism. This confirms the patterns observed in Table 2. One possible reason why we observe these patterns may have to do with PRP and bonus payments – which, as the raw data suggests, are more likely to characterize employment contracts in "white collar" jobs.

This analysis contributes to shed some light on the possible mechanisms underlying the results in Table 2. Thyroid dysfunctions do not appear to play an important role in the choice between white- and blue-collar jobs.[17] Nevertheless, given that individuals are not exogenously assigned to their occupation, the estimates may not necessarily reflect causal relationships.

5. Conclusions

Thyroid disease may have potentially serious implications on individuals' life and working ability. To our knowledge, this is the first paper to examine the impact of thyroid dysfunctions on the labour market outcomes of those affected. Utilizing the first 8 waves of the UKHLS, we have assessed the effect that both undetected and diagnosed (and therefore potentially treated) thyroid disease may have on various labour market outcomes. Overall, our analysis suggests that the labour market burden of the disease is reduced with diagnosis and (presumably) treatment of thyroid diseases. Specifically, our estimates suggest that female individuals who suffer from undetected hypothyroidism experience a 5% wage penalty, compared to female individuals with no thyroid dysfunction. However, once the condition is diagnosed, and hence treatment is assumed to commence, they experience wage gains and improve their employment probability. Evidence also suggests that there is gradual improvement of wages, with wage gains progressively increasing over time, exceeding 10% four years after diagnosis. Male individuals on the other hand, do not appear to be affected by thyroid dysfunctions, as we do not observe similar adverse effects on wages. Our conjecture that the estimated wage effects might be driven by productivity gains appears to be supported by the comparison between people

[16] Estimates available upon request from the authors.

[17] Women before and after diagnosis of hypothyroidism are estimated to have the same probability of holding a white-collar job. In addition, the differences between women who have not yet been diagnosed with hypothyroidism and women who do not have and will not develop thyroid dysfunctions are marginal. The estimates are available from the authors upon request.

Table A1
Wages (mediation analysis).

	Model 1		**Model 2**		**Model 3**		**Model 4**	
Thyroid	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	-0.134 ***	-0.133 ***	-0.134 ***	-0.134 ***	-0.133 ***	-0.132 ***	-0.132 ***	-0.131 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Thyroid	-0.037 **	0.028	-0.037 **	0.028	-0.037 **	0.029	-0.038 **	0.026
	(0.017)	(0.038)	(0.017)	(0.039)	(0.017)	(0.038)	(0.018)	(0.039)
Female x Thyroid		-0.081 *		-0.081 *		-0.082 *		-0.080 *
		(0.043)		(0.043)		(0.043)		(0.044)
Number of obs.	143502	143502	143501	143501	143501	143501	134039	134039
Hyperthyroidism	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	-0.133 ***	-0.132 ***	-0.133 ***	-0.133 ***	-0.131 ***	-0.131 ***	-0.130 ***	-0.130 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Thyroid	-0.048	0.017	-0.048	0.020	-0.048	0.020	-0.038	0.024
	(0.036)	(0.101)	(0.036)	(0.101)	(0.036)	(0.101)	(0.038)	(0.103)
Female x Thyroid		-0.081		-0.084		-0.084		-0.076
		(0.107)		(0.107)		(0.107)		(0.110)
Number of obs.	145548	145548	145547	145547	145547	145547	135986	135986
Hypothyroidism	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	-0.134 ***	-0.133 ***	-0.134 ***	-0.134 ***	-0.133 ***	-0.132 ***	-0.132 ***	-0.131 ***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Thyroid	-0.037 *	0.031	-0.036 *	0.030	-0.036 *	0.031	-0.041 **	0.026
	(0.020)	(0.037)	(0.020)	(0.037)	(0.020)	(0.037)	(0.020)	(0.038)
Female x Thyroid		-0.085 **		-0.083 *		-0.085 **		-0.084 *
		(0.043)		(0.043)		(0.043)		(0.045)
Sample Size	144145	144145	144144	144144	144144	144144	134644	134644

The dependent variable is the logarithm of hourly wages and the estimation method is random-effects. Model 1 does not control for any comorbidities, Model 2 controls for 14 other health conditions, excluding clinal depression, Model 3 controls for 15 other health conditions, including clinical depression, and Model 4 does not control for other comorbidities but includes physical and mental component summary scores (PMS and MCS). The numbers in parentheses are standard errors clustered by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by *** , ** and * , respectively. The sample consists of those employed (excluding self-employed individuals).

who are on PRP contracts or receive bonus payments and those whose remuneration package does not include such performance-related payments.

The adverse impact of hypothyroidism on wages is driven by women, who seem to be disproportionally affected more than men. As a result, undiagnosed hypothyroidism appears to amplify existing gender inequalities in the labour market. Indeed, the gender pay gap is found to widen for women who have not yet been diagnosed (and hence treated) with hypothyroidism. Given the high prevalence of thyroid dysfunctions, and in particular hypothyroidism, among the female population, our findings highlight another potential explanation on the gender wage gap, to our knowledge hitherto overlooked in the literature. The issue of narrowing the gender wage gap remains a key policy priority. Our analysis can prove valuable in formulating relevant policy interventions and initiatives in the labour market to redress such gender disparities, suggesting the need to consider how health conditions may be contributing factors.

The debate in the medical profession as to when to start treatment is ongoing and there is evidence that diagnosis of thyroid disease does not always lead to treatment. Our analysis based on the UKHLS dataset cannot capture the full magnitude of the adverse labour market effects of the thyroid problem, as we do not know whether individuals started to receive treatment upon diagnosis. As a result, we have made the assumption that diagnosis correlates with treatment. There is evidence, though, that diagnosis of thyroid disease does not automatically lead to treatment. Crucially, this implies that we cannot make a distinction between subclinical or 'borderline' cases of thyroid disease (where treatment is not prescribed) and cases where individuals receive

Table A2
Wages (other chronic conditions).

	Depression		High Blood Pressure		Diabetes	
Before vs Never	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.133 ***	-0.133 ***	-0.129 ***	-0.127 ***	-0.133 ***	-0.132 ***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
Depression	-0.035 **	-0.038 *				
	(0.012)	(0.022)				
Female x Depression		0.005				
		(0.026)				
High Blood Pressure			-0.021 **	0.001		
			(0.010)	(0.014)		
Female x High Blood Pressure				-0.043 **		
				(0.019)		
Diabetes					-0.019	0.004
					(0.014)	(0.022)
Female x Diabetes						-0.048 *
						(0.028)
Number of obs.	139195	139195	131592	131592	143222	143222

The dependent variable is the logarithm of hourly wages and the estimation method is random-effects. The numbers in parentheses are standard errors clustered by individuals. Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively. The sample consists of those employed (excluding self-employed individuals).

treatment. Therefore, our findings should be interpreted as lower bound estimates of the potential labour productivity improvements individuals may experience once treated for thyroid dysfunction, and in particular hypothyroidism. It is therefore conceivable that the potential benefits of early diagnosis of thyroid dysfunctions may be even larger than what our estimates suggest. The analysis we carry out in this study suggests that, if left undiagnosed, however, it can have a serious negative impact not only on the health and wellbeing of those concerned but also on their labour market prospects. This has important implications for public health, as it suggests that there may be potential productivity gains that may be achieved through the early detection (and treatment) of thyroid dysfunction. Our findings highlight the importance of being tested for thyroid disorders and call for a deeper understanding of the consequences of, in particular, untreated borderline and subclinical hypothyroidism cases which may have adverse effects on individuals' ability to participate in social and work life.

CRediT authorship contribution statement

Catia Montagna: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing **Alexandros Zangelidis:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing.

Data Availability

Data will be made available on request.

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Appendix

Appendix Table A1 and Table A2.

References

Abendroth, A.K., Melzer, S., Kalev, A., 2017. Women at work: women's access to power and the gender earning's gap. ILR Rev. Vol. 70, 190–222.
Altonji, J.G., Blank, R.M., Ashenfelter, O., & Card, D. (1999). "Race and gender in the labor market", Handbook of Labor Economics (edited by Orley C. Ashenfelter and David Card C, 3, 3143–3259).
Bauer, M., Glenn, T., Pilhatsch, M., Pfennig, A., Whybrow, P.C., 2014. Gender differences in thyroid system function: relevance to bipolar disorder and its treatment. Bipolar Disord. 2014 Feb 16 (1), 58–71. https://doi.org/10.1111/bdi.12150. Epub 2013 Nov 19.
Biondi, B., Cappola, A.R., Cooper, D.S., 2019. Subclinical hypothyroidism: a review. JAMA 322 (2), 180.
Blau, F.D., Kahn, L.M., 2000. Gender differences in pay. J. Econ. Perspect. 14 (4), 75–99.
Blau, F.D., Kahn, L.M., 2006. The U.S. gender pay gap in the 1990s: slowing convergence. ILR Rev. Vol. 60, 45–66.
Blau, F.D. and Kahn, L.M. (2016). The gender wage gap: Extent, trends, and explanations, IZA Discussion Paper No. 9656.
Blau, F.D., Kahn, L.M., 2017. The gender wage gap: extent, trends, and explanations. J. Econ. Lit. 55 (3), 789–865.
Bode, H., Ivens, B., Bschor, T., Schwarzer, G., Henssler, J., Baethge, C., 2022. Hyperthyroidism and clinical depression: a systematic review and meta-analysis. Transl. Psychiatry 12, 362.
Brand, F., Thvilum, M., Hegedüs, L., Hiberg Brix, T., 2015. Hyperthyroidism is associated with work disability and loss of labour market income. A Danish register-based study in singletons and disease-discordant twin pairs. Eur. J. Endocrinol. 173, 595–602.
Brito, J.P., Ross, J.S., El Kawkgi, O.M., Maraka, S., Deng, Y., Shah, N.D., Lipska, K.J., 2021. Levothyroxine use in the United States, 2008-2018. JAMA Intern Med., 2021 Oct. 1 181 (10), 1402–1405.
Bryson, A., Theodoropoulos, N., & Forth, J. (2022). "Are women doing it for themselves? Female managers and the gender wage gap", Oxford Bulletin of Economics and Statistics (early view).
Burgos, N., Toloza, F.J.K., Singh, Ospina, N.M., Brito, J.P., Salloum, R.G., Hassett, L.C., Maraka, S., 2021. Clinical outcomes after discontinuation of thyroid hormone replacement: a systematic review and meta-analysis. Thyroid 31 (5), 740–751.
Canaris, G.J., Manowitz, N.R., Mayor, G., Ridgway, E.C., 2000. The Colorado thyroid disease prevalence study. Arch. Intern. Med. 160 (4), 526–534.
Castello, R., Caputo, M., 2019. Thyroid disease and gender. Ital. J. Gend. -Specif. Med. 5 (3), 136–141.
Cooper, D.S., Biondi, B., 2012. Subclinical thyroid disease. Lancet 379 (9821), 1142–1154.
Costa Dias, M., Joyce, R., Parodi, F., 2020. The gender pay gap in the UK: children and experience in work. Oxf. Rev. Econ. Policy 36 (4), 855–881.
Drolet, M., Maunsell, E., Mondor, M., Brisson, C., Brisson, J., Mâsse, B., Deschênes, L., 2005. Work absence after breast cancer diagnosis: a population-based study. Cmaj 173 (7), 765–771.
Franklyn, J.A., Boelaert, K., 2012. Thyrotoxicosis. Lancet 379 (9821), 1155–1166.
Goldin, C., 2014. A grand gender convergence: its last chapter. Am. Econ. Rev. 104 (4), 1091–1119.
Grossman, A., Weiss, A., Koren-Morag, N., Shimon, I., Beloosesky, Y., Meyerovitch, J., 2016. Subclinical thyroid disease and mortality in the elderly: a retrospective cohort study. Am. J. Med. 129 (4), 423–430.
Hage, M.P., Azar, S.T., 2012. The link between thyroid function and depression. J. Thyroid Res. 2012.
Heinesen, E., Kolodziejczyk, C., 2013. Effects of breast and colorectal cancer on labour market outcomes-average effects and educational gradients. Health Econ. Vol. 32 (6), 1028–1042.
Ifcher, J., Zarghamee, H., 2016. Do gender-variant preferences for competition persist in the absence of performance? Econ. Inq. 54 (4), 1918–1930.
Ingoe, L., Phipps, N., Armstrong, G., Rajagopal, A., Kamali, F., Razvi, S., 2017. Prevalence of treated hypothyroidism in the community: Analysis from general practices in North-East England with implications for the United Kingdom. Clin. Endocrinol. 87 (6), 860–864.
Jones, M., Makepeace, G., Wass, V., 2018. The UK gender pay gap 1997–2015: what is the role of the public sector? Ind. Relat.: A J. Econ. Soc. 57 (2), 296–319.
Kassenboehmer, S.C., Sinning, M.G., 2014. Distributional changes in the gender wage gap. ILR Rev. 67 (2), 335–361.
Kvetny, J., Heldgaard, P.E., Bladbjerg, E.M., Gram, J., 2004. Subclinical hypothyroidism is associated with a low-grade inflammation, increased triglyceride levels and predicts cardiovascular disease in males below 50 years. Clin. Endocrinol. 61 (2), 232–238.
Leso, V., Vetrani, I., De Cicco, L., Cardelia, A., Fontana, L., Buonocore, G., Iavicoli, I., 2020. The impact of thyroid diseases on theworking life of patients: a systematic review. Int. J. Environ. Res. Public Health 17, 4295. https://doi.org/10.3390/ijerph17124295.
Lillevang-Johansen, M., Abrahamsen, B., Jorgensen, H.L., Brix, T.H., Hegedus, L.M., 2018. Over- and under-treatment of hypothyroidism is associated with excess mortality: a register-based cohort study. Thyroid 28, 566–574.
Lillevang-Johansen, M., Abrahamsen, B., Jorgensen, H.L., Brix, T.H., Hegedus, L.M., 2019. Duration of over- and under-treatment of hypothyroidism is associated with increased cardiovascular risk. Eur. J. Endocrinol. 180 (6), 407–416.
Manning, A., Saidi, F., 2010. Understanding the gender pay gap: what's competition got to do with it? ILR Rev. 63 (4), 681–698.
Manning, A., Swaffield, J., 2008. The gender gap in early-career wage growth. Econ. J. Vol. 118, 983–1024.
Mendes, D., Alves, C., Silverio, N., Batel Marques, F., 2019. "Prevalence of undiagnosed hypothyroidism in europe: a systematic review and meta-analysis. Eur. Thyroid J. 8, 130–143. https://doi.org/10.1159/000499751.
Minor, T., 2013. An investigation into the effect of type I and type II diabetes duration on employment and wages. Econ. Hum. Biol. Vol. 11 (No. 4), 534–544.
Moran, J., Short, P., Hollenbeak, C., 2011. Long-term employment effects of surviving cancer. Health Econ. Vol. 30 (No. 3), 505–514.
Nexo, M.A., Watt, T., Pedersen, J., Bonnema, S.J., Hegedüs, L., Rasmussen, A.K., Feldt-Rasmussen, U., Bjorner, J.B., 2014. Increased risk of long-term sickness absence, lower rate of return to work, and higher risk of unemployment and disability pensioning for thyroid patients: a danish register-based cohort study. J. Clin. Endocrinol. Metab., Sept. 2014 99 (9), 3184–3192.
NICE. (2019, November 20). Thyroid disease: assessment and management. https://www.nice.org.uk/guidance/ng145/chapter/Context.
Niederle, M., Vesterlund, L., 2007. Do women shy away from competition? Do men compete too much? Q. J. Econ. 122 (3), 1067–1101.
Office for National Statistics (2014). Sickness Absence in the Labour Market", UK.
Okosieme, O., Gilbert, J., Abraham, P., Boelaert, K., Dayan, C., Gurnell, M., Vanderpump, M., 2016. Management of primary hypothyroidism: statement by the British Thyroid Association Executive Committee. Clin. Endocrinol. 84 (6), 799–808.
Olsen, W., Gash, V., Sook, K., & Zhang, M. (2018). "The gender pay gap in the UK: evidence from the UKHLS", Research Report, Government Equality Office.
Organization for Economic Cooperation and Development (OECD)/European Union (EU). (2016). "Health at a Glance: Europe 2016–State of Health in the EU Cycle".
Oxford Economics (2010). The Economic Costs of Arthritis for the UK Economy", Oxford.
Pelkowski, J., Berger, M., 2004. The impact of health on employment, wages, and hours worked over the life cycle. Q. Rev. Econ. Financ. Vol. 44 (No. 1), 102–121.
Ponto, K.A., Merkesdal, S., Hommel, G., Pitz, S., Pfeiffer, N., Kahaly, G.J., 2013. Public health relevance of Graves' orbitopathy. J. Clin. Endocrinol. Metab. 98 (1), 145–152.

Quintana-Garcia, C., Elvira, M.M., 2017. The effect of the external labor market on the gender pay gap among executives. ILR Rev. Vol. 70, 132–159.
Razvi, S., Korevaar, T.I., Taylor, P., 2019. Trends, determinants, and associations of treated hypothyroidism in the United Kingdom, 2005–2014. Thyroid 29 (2), 174–182.
Razvi, S., Shakoor, A., Vanderpump, M., Weaver, J.U., Pearce, S.H., 2008. The influence of age on the relationship between subclinical hypothyroidism and ischemic heart disease: a metaanalysis. J. Clin. Endocrinol. Metab. 93 (8), 2998–3007.
Razvi, S., Weaver, J.U., Butler, T.J., Pearce, S.H., 2012. Levothyroxine treatment of subclinical hypothyroidism, fatal and nonfatal cardiovascular events, and mortality. Arch. Intern. Med. 172, 811–817.
Razvi, S., Weaver, J.U., Vanderpump, M.P., Pearce, S.H., 2010. The incidence of ischemic heart disease and mortality in people with subclinical hypothyroidism: reanalysis of the Whickham Survey cohort. J. Clin. Endocrinol. Metab. 95, 1734–1740.
Reuben, E., Wiswall, M., Zafar, B., 2017. Preferences and biases in educational choices and labour market expectations: shrinking the black box of gender. Econ. J. Vol. 127, 2153–2186.
Rizzo, J.A., Abbott III, T.A., Pashko, S., 1996. Labour productivity effects of prescribed medicines for chronically ill workers. Health Econ. 5 (3), 249–265.
Rumball-Smith, J., Barthold, D., Nandi, A., Heymann, J., 2014. Diabetes associated with early labor-force exit: a comparison of sixteen high-income countries. Health Aff. 33 (1), 110–115.
Rycx, F., Tojerow, I., 2004. Rent sharing and the gender wage gap in Belgium. Int. J. Manpow. Vol. 25, 279–299.
Saliba, B., Paraponaris, A., Ventelou, B., 2007. Situations regarding the labour market for people suffering from chronic diseases. Rev. d'Epidémiologie Et. De. St. Publique Vol. 55 (No. 4), 253–263.
Schäfer, K.C., Schwiebert, J., 2018. The impact of personality traits on wage growth and the gender wage gap. Bull. Econ. Res. 70 (1), 20–34.
Taylor, P.N., Albrecht, D., Scholz, A., Gutierrez-Buey, G., Lazarus, J.H., Dayan, C.M., Okosieme, O.E., 2018. Global epidemiology of hyperthyroidism and hypothyroidism. Nat. Rev. Endocrinol. 14, 301–316.
Taylor, P.N., Iqbal, A., Minassian, C., Sayers, A., Draman, M.S., Greenwood, R., Hamilton, W., Okosieme, O., Panicker, V., Thomas, S.L., Dayan, C., 2014. Falling threshold for treatment of borderline elevated thyrotropin levels-balancing benefits and risks: evidence from a large community-based study. JAMA Intern Med. 174 (1), 32–39.
Thvilum, M., Brandt, F., Brix, T.H., Hegedus, L., 2014. Hypothyroidism is a predictor of disability pension and loss of labor market income: a Danish register-based study. J. Clin. Endocrinol. Metab. 99 (9), 3129–3135.
Tunceli, K., Bradley, C.J., Nerenz, D., Williams, L.K., Pladevall, M., Elston Lafata, J., 2005. The impact of diabetes on employment and work productivity. Diabetes Care 28 (11), 2662–2667.
Vanderpump, M.P., 2011. The epidemiology of thyroid disease. Br. Med. Bull. 2011 (99), 39–51.
Weichselbaumer, D., Winter-Ebmer, R., 2005. A meta-analysis of the international gender wage gap. J. Econ. Surv. 19 (3), 479–511.
Wiswall, M., Zafar, B., 2017. Preference for the workplace, investment in human capital, and gender. Q. J. Econ. Vol. 133, 457–507.