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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 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

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). More specifically, looking at the effect of specific chronic diseases, people with diabetes work fewer hours, are found to be more likely to choose a part-time work (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 from 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.

Despite the body of evidence on various chronic diseases, we know comparatively little about how thyroid dysfunctions affect labour market outcomes. Thyroid disease has 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, and with thyroid patients being at greater risk of long-term sick leave and impairment of working ability (for a recent survey see Leso *et al*, 2020).

The aim of this paper is to shed some light on the labour market outcome implications of thyroid disease. A number of important stylised facts 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. Fourth, undiagnosed thyroid disorder (particularly hypothyroidism) is frequent (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 (Costello and Caputo, 2019). Fifth, in women symptoms tend to persist longer and are less effectively managed by therapy (Costello and Caputo, 2019).

In light of these stylised 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 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).

We find 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.

Thyroid dysfunction can easily be identified and, in most cases, treated. 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 and concluding remarks are provided in section 5.

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 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, 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.

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; 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% to 1.3% (Taylor et al, 2020). 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% to 5.3% and between 0.3% and 3.7% in Europe and the US respectively (Taylor et al, 2018: citing: Asvold et al, 2013; McGrogan et al, 2008; Canaris et al, 2000). This thyroid disorder is about 10 times more prevalent in women than in men. Current evidence suggests that a considerable proportion of hypothyroidism cases in Europe consists of subclinical hypothyroidism, which is often undiagnosed (Mendes et al, 2019).

3. Data, descriptive statistics, and methodology

For our empirical analysis, we use data from the first eight waves of UKHLS that cover the period 2009-2018. The sample is restricted to female and male individuals aged 18-65.[1] 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.[2]

Table 1 below gives the descriptive statistics for our sample from which emerge stylised facts that are broadly consistent with the medical literature. Female individuals have a higher incidence of thyroid dysfunction and this is true for both hyperthyroidism and hypothyroidism. In addition, individuals diagnosed with hypothyroidism are three times more than those diagnosed with hyperthyroidism.

[1] 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.

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

This holds true for both males and females. Finally, people are typically diagnosed with thyroid dysfunctions in their mid 40s.

Table 1: Descriptive Statistics

	All	Female	Male	T-test (m_m-m_f)
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)	
Obs	239,770	132,337	107,443	
Age detected				
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)	

Note: (i) Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively.

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. The estimation framework is thus described by the following equation:

$$y_{it} = \beta_0 + \beta_1 female + \beta_2 Thyroid_{it} + \boldsymbol{X}_{it}\boldsymbol{\gamma} + \varepsilon_{it} \quad (1)$$

where y refers to the labour market outcome of interest of individual i at period t, $female$ is a gender control variable which takes the value of one for female and zero otherwise, and $Thyroid$ is a control variable for thyroid disease which takes the value of one for those affected by thyroid disease and zero otherwise. The model also includes a vector $\boldsymbol{X}$ of individual and, when applicable, work-related characteristics, including regional and time fixed effects. Specifically, the demographic variables include controls for age, marital status, education, and other health conditions. The work-related variables include controls for full-time job, permanent contract, private sector, occupation and industry. Finally, ε is the random error component. In order to explore potential gender differences in how thyroid disease may affect labour market outcomes, equation (1) is also extended to include an interaction term between gender and thyroid disease:

$$y_{it} = \beta_0 + \beta_1 female + \beta_2 Thyroid_{it} + \beta_3 female \cdot Thyroid_{it} + \boldsymbol{X}_{it}\boldsymbol{\gamma} + \varepsilon_{it} \quad (2)$$

Throughout the paper we 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, we make three different comparisons, utilising the relevant sample. Specifically, we first compare individuals who are not yet diagnosed but who will be diagnosed at some point during the sample period ("Before") with those who are not diagnosed and will not be diagnosed with thyroid disease throughout the sample period ("Never"). We then compare individuals who have already been diagnosed with thyroid disease ("After") with those individuals who will not be diagnosed with thyroid disease at any point during the sample period ("Never"). Finally, we compare individuals who have already been diagnosed with thyroid disease against those who will be diagnosed later during the sample period ("After" vs "Before").

4. Results

In this section, we consider the effects of thyroid disease on a number of labour market outcomes: wages, labour force participation, employment status, and weekly working hours.

The tables below are divided into three panels: (I) Before vs Never, (II) After vs Never and (III) After vs Before. The first comparison, in panel (I), allows us to explore the effect of undetected thyroid problems on labour market outcomes. If we assume that those diagnosed with thyroid dysfunction are given the appropriate treatment, in the latter two comparisons, panels (II) and (III), we can then see how detection of and therapy for thyroid diseases may 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 give the effects of thyroid disease on wages, where the logarithm of hourly wages is the dependent variable. All equations are estimated using random effects, with standard errors clustered by individuals. This approach is preferred over a fixed effects model as 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.

As can be seen from the first panel of the table, individuals who will in the future but have not yet been diagnosed with a thyroid dysfunction (undetected case of thyroid condition) 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 the specification presented in column (2), we explore whether there are gender differences in the effect of undetected thyroid dysfunctions. The results reveal that the previous estimated negative wage differential effect is driven by female workers. Although, no wage differences are found when comparing male individuals with undetected thyroid dysfunctions with male workers that do not have a thyroid condition, there is a wage penalty for female individuals with undetected thyroid dysfunctions. According to our estimates, the "adjusted"[3] gender wage gap between male and female individuals with no thyroid dysfunctions is around 13%. However, the gap widens for the female individuals with undetected thyroid conditions, as they receive 5.3% lower wages than comparable female individuals with no thyroid dysfunctions. A further investigation into the type of thyroid disease suggests that this result, in turn, is driven by female workers who will be diagnosed with hypothyroidism, who have 5.4% lower hourly wages, compared to female workers with no thyroid dysfunctions. This 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.

Gender differences in earnings have been a persistent phenomenon in the UK labour market. Although there has been progress in bridging the pay gap over the last century, gender disparities remain sizeable (Costa Dias et al., 2020). According to a recent ONS (2021) report, while the gender gap[4] has been steadily decreasing over the last 20 years, it still was around 15.4% by 2021. Also, our estimates suggest that the gender wage gap widens when female individuals suffer from yet undiagnosed

[3] The regression analysis provides a measure of the wage gap between male and female workers, controlling for differences in their observable individual and workplace characteristics. This is different to measurements of unadjusted gender wage gap that rely on raw data comparisons.

[4] Figures are based on median gross hourly earnings among all employees.

hypothyroidism. Therefore, it is important to assess whether the detection, and presumably subsequent treatment, of thyroid disease may potentially help in reducing the gender wage gap. In the second panel, we compare those who have been diagnosed to those who have not and will not be diagnosed with a thyroid dysfunction over the sample period. We find that after diagnosis, where we assume treatment begins, individuals recover the wage penalty and the negative wage effect disappears: there are no wage differences between those who have been diagnosed with a thyroid condition and those who do not (and will not in the future) have a thyroid condition. To the extent that diagnosis might lead to treatment, this result suggests that discovering and dealing with the thyroid dysfunction eliminates the previous negative impact of the undiagnosed disease on wage differentials.

To further check the importance of diagnosis, in the last panel of the table we compare individuals who have already been diagnosed with thyroid disease to those who will be diagnosed. The results suggest that post-diagnosis individuals earn higher wages, confirming the importance of diagnosis. This effect is entirely driven by female employees. Specifically, when comparing female individuals before and after diagnosis, there is a roughly 5% difference in wages, suggesting that they recover the previously incurred wages losses when thyroid dysfunction was undetected. Furthermore, it is only those with hypothyroidism who experience an increase in wages once the condition is diagnosed. Unobserved individual heterogeneity may potentially cast doubt on the validity of the estimates. For instance, individuals with certain types of preferences and attitudes towards risk may go more often to see a doctor and thus may be more likely to be diagnosed with a thyroid condition. Similarly, preferences may affect labour productivity and wages. In the estimates presented in panel (III), effectively we compare the same group of people before and after diagnosis, so any such unobserved individual heterogeneity should not matter, as it is expected to equally affect both periods of time. Therefore, we are confident that the estimated wage effects are not affected by unobserved individual heterogeneity. The results presented in Table 2 are also confirmed when stratifying the sample by gender and estimating the wage equations separately for male and female workers.[5]

These results suggest that untreated hypothyroidism has an adverse effect on female workers' wages. However, 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, 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 of the diagnosis of a chronic disease from its treatment on labour market outcomes is important (Rizzo et al., 1996). However, whether individuals receive some medication or treatment, once thyroid dysfunction is diagnosed, is not reported in the UKHLS data. Thus, the wage improvement observed for women, once hypothyroidism is diagnosed, should be interpreted as a lower bound estimate, as it may well be the case that not all those diagnosed with thyroid conditions received treatment. If all people diagnosed were to receive treatment, the wage effect may potentially be larger.

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

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)
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)
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)
Obs	5,239	5,239	1,273	1,273	3,966	3,966

Notes: Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively. The sample consists of those employed (excluding self-employed individuals). The estimates are based on random-effects with cluster (by individuals) standard errors.

The estimates in Table 2 suggest that female with undetected hypothyroidism experience a 5% wage penalty, compared to their female peers that do not have thyroid problems. However, after diagnosis, and presumably with the start of treatment, they appear to recover this wage loss. This 5% wage decrease/increase is an average estimate for the period before/after the diagnosis, but it does not tell us how the wage profile evolves over time, in relation to when diagnosis takes place. To explore this, we re-estimate the wage equation model, focusing only on individuals who at some point during the sample period are diagnosed with a thyroid dysfunction. For the analysis, we consider a maximum of five year before and after the diagnosis of a thyroid condition, and we include a set of time dummy variables, controlling for the period before or after diagnosis. The sample is stratified by gender and the wage equation estimates are presented in Table 3.

Table 3: Timing of diagnosis and wages

	Thyroid		Hyperthyroidism		Hypothyroidism	
Period	Female	Male	Female	Male	Female	Male
T-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)
T-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)
T-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)
T-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)
T-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)
Diagnosis T0 (reference period)						
T+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)
T+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)
T+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)
T+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)
T+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)
Obs	1995	514	530	119	1465	395

Notes: 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. The estimates are based on random-effects with cluster (by individuals) standard errors.

The estimates in Table 3 confirm the gender differences also observed in Table 2. Female individuals are found to be adversely affected by undetected thyroid dysfunctions, but after diagnosis they experience wage gains, specifically in the case of hypothyroidism. Furthermore, there are a few other observations we can make from Table 3. The effects of undetected thyroid dysfunctions are evident even five years before diagnosis, with associated wage penalties 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 be bigger than the 5% increase suggested from Table 2, panel (III), as the latter is an average estimate for the period after diagnosis. 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, such as individuals' labour force participation, employment status, and working hours.

For the labour force participation model, we consider a binary outcome variable that takes the value of one for individuals who are economically active (employed, self-employed or unemployed) and zero otherwise (retired or at home). Random effect linear probability models[6] with standard errors clustered by individuals are estimated and the corresponding coefficients are reported in Table 4 below. The results suggest that neither undetected nor diagnosed thyroid disease seem to affect labour force participation. This is true for both individuals with hyperthyroidism and hypothyroidism.

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

Note: Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively. The estimates are based on a linear probability model using random-effects with cluster (by individuals) standard errors.

Next, we focus on the workforce, i.e. those who are economically active, and estimate a model on individuals' employment status. The dependent variable is a categorical variable (1: self-employed, 2: employed, and 3: unemployed) and the results, based on multinomial logit models with standard errors clustered by individuals, are presented in (Table 5).

[6] The estimates 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

Note: Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively. The referent group is "employed". The estimates refer to coefficients, based on multinomial logit with cluster (by individuals) standard errors.

The reported coefficients 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 reference group (employed). Thyroid disease, both undetected and diagnosed, does not make individuals more likely to be self-employed than employed. Also, whilst an undetected thyroid dysfunction is estimated to increase the multinomial log-odds of being unemployed relative to employed, there is some evidence that the employment prospects of individuals seem to improve when thyroid disease is diagnosed. This is particularly true for female individuals diagnosed with hypothyroidism. Specifically, the predicted probability of being unemployed reduces for female individuals by 3 percentage points, from 9% to 6%, after hypothyroidism is diagnosed, and treatment is assumed to commence.

Finally, in Table 6 we assess whether thyroid disease affects individuals' labour supply at the intensive margin. The outcome variable used 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.

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

Note: Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively. The sample consists of those employed (excluding self-employed individuals). The dependent variable is the logarithm of number of hours normally worked per week, including overtime paid hours. The estimates are based on random-effects with cluster (by individuals) standard errors.

The results suggest that, once diagnosed with hyperthyroidism, male workers adjust their working hours downwards (-1.8 hours 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.

Overall, the estimates do not suggest that 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.

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), we do not observe any significant change, especially in relation to their labour force participation decision and their working hours. 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 interest anyone in the sample following diagnosis: the start years of employment or change of employment all occur before the year of diagnosis. Hence, it follows that the pay increase observed must occur in their current 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 control for the presence of performance related pay (PRP) or bonuses. Since information on PRP and bonuses is recorded only every other wave (waves 2, 4, 6, 8), the sample reduces roughly to half.

We therefore stratify the sample by remuneration type and re-estimate the wage equation models. The analysis below sheds some light on the underlying mechanism that may explain 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 donot seem to affect this choice of contract. Indeed, an analysis on the probability of having a PRP or bonus contract suggests that there are no differences among individuals with undiagnosed or diagnosed thyroid conditions and those with no thyroid problems[7]. Even so, some caution is required when interpreting the results as the estimates may not necessarily reveal causal relationships. These results are important, nevertheless, as they shed light on what may drive the wage gains observed after diagnosis.

In the results presented in the third panel of Table 7 (After vs Before), the wage gains observed when comparing individuals who are diagnosed with hypothyroidism to those before they are diagnosed (Table 2, panel (III)) are evident only in the 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. 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 though once hyperthyroidism is diagnosed and treated, since there is no wage difference between male workers diagnosed with hyperthyroidism and male workers who are not and will not be diagnosed with hyperthyroidism. In addition, female individuals are estimated to experience a larger wage gain than male individuals when hyperthyroidism is diagnosed.

[7] Estimates available upon request from the authors.

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

Note: Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively. The sample consists of those employed (excluding self-employed individuals). The estimates are based on random-effects with cluster (by individuals) standard errors.

Finally, in Table 8 we explore differences between "white" and "blue collar" workers, by stratifying the sample based on occupation. As discussed above, given that individuals are not exogenously assigned to their occupation, the estimates may not necessarily reflect causal relationships. Nevertheless, they may shed light on the possible underlying mechanisms that drive the results in Table 2. Female "white collar" workers experience lower wages before the hypothyroidism diagnosis. However, once diagnosed, we see that they experience wage gains compared to their male peers also diagnosed with hypothyroidism. This confirms the patterns observed in Table 2. One reason why we observe these patterns may have to do with PRP and bonus payments – which, the raw data suggests, are more likely to characterise employment contracts in "white collar" jobs.

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

Note: Level of statistical significance at 1%, 5% and 10% is denoted by ***, ** and *, respectively.

5. Conclusions

Thyroid disease may have potentially serious implications on individuals' life and working ability. In this paper, utilising 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. As a result, undetected hypothyroidism further widens the existing gender wage gap. 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 who are on PRP contracts or receive bonus payments and those whose remuneration package does not include either PRP or bonus payments. These findings highlight another potential explanation or the gender wage gap, to our knowledge hitherto overlooked in the literature.

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 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 treatment for thyroid dysfunctions may be even larger than what our estimates suggest. Thyroid dysfunction can easily be identified and, in most cases, treated. 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 often have adverse effects on individuals' ability to participate in social and work life.

In addition, the issue of narrowing the gender wage gap remains a key policy priority. Our study suggests that thyroid dysfunctions, in particular hypothyroidism, contribute to amplifying existing gender inequalities in the labour market. In so doing, our analysis can prove valuable in in formulating relevant policy interventions and initiatives in the labour market to redress gender disparities.

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