The Effect of Migrant Regularization on Labor Exploitation*

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October 21, 2025

Abstract

This paper shows that granting migrants legal status reduces labor exploitation. We study Spain's 2005 large-scale regularization program, which granted legal status to 600,000 undocumented migrants. We proxy labor exploitation with hospitalizations for heat-related illnesses among working-age individuals, capturing exposure to hazardous working conditions in outdoor occupations. We implement a triple-difference design that exploits cross-provincial variation in pre-reform shares of undocumented migrants and temporal variation in extreme temperatures. Our results show that the incidence of heat-related hospitalizations during heatwaves declined significantly in provinces with greater exposure to the amnesty. Specifically, an additional day above 35°C became 3.3 percentage points less likely to result in heat-related hospitalization in highly exposed provinces, representing a 9.4% reduction relative to the pre-reform mean. Our findings demonstrate that migrant regularization is a powerful policy for improving worker well-being and reducing their vulnerability to extreme climatic events.

Keywords: amnesty programs, working conditions, exploitation, extreme heat

JEL Classification: J46, J47, J61, Q54, I12

*We would like to thank Cevat Aksoy, Cristina Bratu, Ralph De Haas, Ferran Elias Moreno, Tommaso Frattini, Albrecht Glitz, Libertad González, Gianmarco León-Ciliotta, Luigi Minale and Giacomo Ponzetto for helpful comments and discussion. We would also like to thank participants at the Migration Observatory 9th Annual Conference at Collegio Carlo Alberto in Turin.

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1 Introduction

Labor exploitation is a prevalent phenomenon in labor markets across the world. According to the International Labor Organization, an estimated 27.6 million workers are subjected to exploitation—defined as work performed without consent and under threat of penalty. Migrant workers are especially vulnerable, facing a risk of labor exploitation that is three times higher than for native workers [ILO et al., 2022]. Undocumented migrants may be particularly at risk: their exclusion from formal labor markets could compel them to accept hazardous and exploitative jobs in the informal sector. Estimates indicate that the European Union (EU) hosts around 3.9 to 4.8 million undocumented migrants, and the United States (US) up to 11 million [Kierans and Vargas-Silva, 2024; Passel and Krogstad, 2024]. These numbers are likely to increase in the near future due to armed conflicts, political instability and climate change in developing countries, and restrictive migration policies in developed ones.

Understanding and quantifying the relationship between legal status and exploitation is key, not only because labor exploitation constitutes a severe human rights violation, but also because it may distort market competition by allowing noncompliant firms to operate at lower cost. However, testing empirically whether legal status affects exploitation poses three main challenges. First, identifying a causal effect requires suitable policy variation. Second, most countries lack detailed data on the prevalence and spatial distribution of undocumented migrants. Third, due to its illegal nature, measuring labor exploitation is challenging, and reliable data do not exist.

This paper addresses these challenges by leveraging a large-scale regularization reform in Spain and combining administrative, health, and climate data. In 2005, the Spanish government implemented a one-time regularization program that granted legal status to approximately 600,000 undocumented migrants. We use this policy as a quasi-experiment to estimate the impact of legalization on working conditions. We measure policy exposure at the province level as the share of undocumented migrants over total population. Undocumented migrants in Spain are strongly incentivized to register in the municipal population registry, as doing so grants access to public health and education services. This enables us to reliably estimate the size of the undocumented population in each province by comparing the number of registered foreign residents to the number of valid work permits prior to the reform. We focus on heat-related hospital discharges (HRDs) among working-age individuals as a proxy for exploitative labor. This approach is motivated by two facts. First, migrants are overrepresented in outdoor jobs, mainly agriculture and construction. Second, strenuous physical activity under high temperatures is the primary cause of heat-stroke in the working-age population [Epstein and Yanovich, 2019].

To identify the effect of legal status on labor exploitation, we implement a triple-difference design that exploits the timing of the 2005 amnesty program, cross-provincial variation in exposure to the reform, and variation in temperature across provinces and over time. We test whether the elasticity of HRDs to excessive heat declines after the reform, particularly in provinces more exposed to it. Our estimates indicate that, post-amnesty, an additional day with a maximum temperature above 35 °C is associated with a 3.3 percentage point lower probability of observing any HRD in more exposed provinces relative to less exposed ones - a 9.4% decline relative to the pre-amnesty mean of 0.351 percentage points in months with at least one very hot day. We interpret this as evidence of improved working conditions among migrant workers who gained legal status through the reform. These results hold true across different specifications in which we refine the exposure measure considering the share of undocumented migrants employed in agriculture and we exclude the provinces of Barcelona and Madrid from the sample.

We also shed light on the mechanism driving the main result. We find that migrants transitioned away from agriculture, a sector with notoriously poor working conditions, to other sectors with better conditions, chiefly to construction. In provinces more exposed to the amnesty, the agricultural share of migrant employment decreased by 4 percentage points, while the construction share increased by 5 percentage points. Obtaining a formal working contract in agriculture was the stepping stone to move to better employment opportunities. Two years after the amnesty, 70% of migrants regularized in agriculture had moved to other sectors, of which 24% to construction, which was their largest destination. By contrast, only 34% of those regularized in construction had left the sector, and virtually none switched to agriculture.

This paper contributes to three strands of the literature. First, it adds to studies on labor exploitation by examining the role of migrant regularization, which has received limited attention. While much of the existing work has focused on the historical roots of labor coercion [Acemoglu and Wolitzky, 2011; Naidu and Yuchtman, 2013; Ashraf et al., 2024; Dippel et al., 2020], more recent studies have turned to contemporary drivers, including imperfect competition in labor markets [Naidu et al., 2016], migration flows [Seifert and Valente, 2018], the presence of criminal organizations [Dipoppa, 2024], and the political environment [Carillo et al., 2023]. Yet, the impact of granting legal status to undocumented migrants on labor exploitation remains largely unexamined.

Second, we add to the literature on the labor market consequences of amnesty programs. Previous papers have studied how granting legal status to undocumented migrants affects their employment and earnings outcomes [Cobb-Clark et al., 1995; Kossoudji and Cobb-Clark, 2002; Kaushal, 2006; Amuedo-Dorantes et al., 2007, 2012; Devillanova et al., 2018; Bahar et al., 2021; Fasani et al., 2021]. Most closely related to this paper, Elias et al. [2025] show how the 2005 Spanish amnesty program increased the employment prospects of migrants in the formal labor market without affecting native employment. We contribute to this work by focusing on non-wage working conditions. We provide novel evidence that regularization decreases exposure to labor exploitation.

Finally, our study contributes to the literature in economics and epidemiology on climate and health. So far, the literature has documented a robust relationship between extreme temperature and mortality, and how it is affected by adaptation and climate change [Barreca et al., 2016; Carleton et al., 2022; Ballester et al., 2023]. We contribute by highlighting the role of legal status and working conditions in explaining the relationship between extreme heat and morbidity.

The remainder of the paper is organized as follows. Section 2 provides the institutional background. Section 3 describes the data sources and variables that we use in the empirical analysis. Section 4 presents the identification strategy. Section 5 shows the results. Section 6 concludes.

2 Institutional Background

Spain offers a unique setting for studying the effect of amnesty programs on working conditions. Undocumented migrants in Spain have a strong incentive to register in the *Padrón Municipal* (Municipal Registry of Population) because registration confers access to public healthcare and education under the same conditions as Spanish nationals and regular migrants.[1] This feature allows us to credibly measure the size of the undocumented migrant population by comparing the number of foreign residents recorded in the *Padrón* with the number of valid residency and work permits issued annually (see Section 3). Moreover, the country has a large informal economy, which provides employment opportunities for undocumented migrants [González-Enríquez, 2009]. Undocumented migrants are disproportionately employed in agriculture, construction and hospitality – sectors characterized by poor work-

[1] This right was suspended in 2012 and reinstated in 2018. Hence, undocumented migrants have a strong incentive to register throughout the entire study period (2000-2011).

ing conditions, including exposure to health risks, long working hours, job instability, low wages, and high levels of informality. Conditions in agriculture are notoriously very poor: 37% of agricultural workers in the EU report being exposed to excessive heat, higher than any other sector and more than twice the average (15%).[2] In Spain, this is likely to be much higher.[3] Numerous studies have documented high exposure to health risks and work-related accidents [Ekmekci and Yaman, 2024; de Assis et al., 2021].

The prevalence of undocumented migration varies substantially across Spain. Figure 1 panel (a) shows the distribution across provinces of undocumented migrants in 2004, the year before the reform. They are more concentrated in eastern Spain and, as expected, in provinces where the agricultural sector is larger. The spatial distribution of undocumented migrants working in agriculture is similar to the distribution of undocumented migrants overall – see Figure A.1 in the Appendix.

Between February and May 2005, the Spanish government implemented a large-scale regularization program that granted legal status to approximately 600,000 undocumented migrants. The program targeted individuals with prior residence in the country and ties to the Spanish labor market. To qualify, applicants had to be registered in the *Padrón* before August 2004 and obtain a valid job offer: a minimum six-month contract for general employment and a minimum three-month contract for agricultural work.[4] The policy was accompanied by an increase in the number of work inspections to ensure compliance [Elias et al., 2025].

The scale and timing of the amnesty were largely unanticipated. In 2002, the ruling center-right government led by the People's Party (PP) had ended all extraordinary regularization programs. As of early 2004, forecasts predicted their re-election, in which case they would have been unlikely to adopt more pro-migration policies. However, the terrorist attacks of March 11th, 2004 and the government's response in the aftermath led to an electoral upset for the incumbent party. As a result, and unexpectedly, the center-left Socialist Party (PSOE) won the following election and formed a new government. For additional details, see Montalvo [2011]; Elias et al. [2025].

Panel (b) of Figure 1 shows one of the key outcomes of the reform. The red line shows the share of migrants in the Labor Force Survey (LFS), which includes both formal and informal workers. The blue line shows the evolution of the share of migrants in the Social Security

[2] Source: European Working Conditions Survey 2024. The question asks: "*How often are you exposed at work to high temperatures which make you perspire even when not working?*".

[3] Unfortunately, a breakdown by sector and country is not available, but Spain's average for all sectors is 28%, compared to 15% in the EU.

[4] Additional exceptions applied in sectors such as construction and domestic work.

records, thus capturing only formal employment. Immediately after the amnesty, the share of migrants in social security rose from around 6 to 9%, closing the gap with the migrant share in the LFS.[5] At the same time, the estimated share of undocumented migrants (purple line) fell sharply.[6] This shows that the policy was successful in moving undocumented migrants from informal to formal employment. The transition of migrant workers from informal to formal jobs was concentrated in provinces with a high share of undocumented migrants, while provinces with few migrants saw less notable changes (see Appendix Figure A.2).

Because undocumented migrants already had access to public healthcare, the amnesty only impacts their ability to be employed in formal labor markets. Hence, the effect that we measure on hospital discharges is likely to materialize through changes in working conditions rather than changes in demand for healthcare. It can still be the case, however, that regularized migrants are more inclined to seek medical help than undocumented ones. We take this issue seriously and examine how it may impact the interpretation of our results at the end of Section 4.

3 Data

Municipal Registry Our first data source is the Spanish Municipal Registry (*Padrón*) to measure the population in each municipality from 2000 to 2007. The registry records each resident's nationality, allowing us to construct annual province-level aggregates of the native and foreign-born population, further disaggregated by EU and non-EU citizenship. Our analysis focuses on non-EU migrants, as EU citizens have the right to work in Spain by default and are therefore not directly affected by the amnesty program. As explained above, undocumented migrants are allowed—and strongly encouraged—to register in the *Padrón*, making it a reliable source for measuring the *de facto* population regardless of legal status.

Reform Exposure To estimate the size of the undocumented migrant population, we combine data from the *Padrón* with administrative records on valid residency permits, which include both work and student permits. For each province and year, we calculate the stock of undocumented migrants as the difference between the number of registered foreign residents

[5] We access Social Security records through the *Muestra Continua de Vidas Laborales* (MCVL), which provides individual-level data on the employment histories of a representative sample of workers affiliated with the Spanish social security system. As such, it is representative of the formal labor force.

[6] Note that this is similar to the difference between the share of migrants in the LFS and the Social Security records.

and the number of valid permits. This measure is further disaggregated by EU and non-EU citizenship.

We define a province's exposure to the amnesty program as a function of the share of the undocumented population over the total population. Specifically, our exposure variable is

$$ShUndoc_p = \frac{\text{Migrants}_p - \text{Residency Permits}_p}{\text{Population}_p} = \frac{\text{Undocumented}_p}{\text{Population}_p}$$

where all values refer to 2004, the year before the amnesty program. To simplify the interpretation of the coefficients, we classify provinces as either exposed or not exposed using a median split, thus defining the dummy variable:

$$HiUndoc_p = \mathbb{1}\{p : ShUndoc_p > Median(ShUndoc)\}$$

Our main results are robust to using the continuous share rather than the dummy variable.

Reform Exposure in Agriculture In the second part of the analysis, we refine our exposure measure to better capture the relative size of the undocumented migrant population employed in the agricultural sector. To this end, we use the *Encuesta de Población Activa* (EPA), a quarterly household survey that provides information on sectoral employment shares by nationality. The EPA asks whether respondents worked during the previous week, regardless of legal status, thereby capturing both formal and informal workers.

Using these data, we compute the share of migrants employed in agriculture at the province-year level as

$$ShAgri_p = \frac{\text{Migrants in Agriculture}_p}{\text{Migrant Employees}_p}$$

We then proxy for the relative size of the undocumented migrant population working in agriculture using the following measure:

$$ShAgriUndoc_p = \frac{\text{Undocumented}_p \times ShAgri_p}{\text{Population}_p}$$

where all variables refer to the year 2004. This proxy is valid under the assumption that the agricultural employment share among undocumented migrants is similar to that among documented migrants. As before, we use a median split to construct a binary indicator:

$$HiAgriUndoc_p = \mathbb{1}\{p : ShAgriUndoc_p > \text{Median}(ShAgriUndoc)\}$$

Hospital Discharges To measure health hazards, we use data from the *Encuesta de Morbilidad Hospitalaria* (Hospital Morbidity Survey, EMH), an annual survey conducted by Spain's National Institute of Statistics (INE) since 1977. The EMH collects information on hospital discharges from public, private, and military hospitals nationwide, drawing from administrative records and hospital admission logs. The unit of observation is the single discharge, that is, the release of a patient after at least one night in the hospital. It includes the standardized diagnostic code (ICD-9-CM) of the principal diagnosis, length of stay, type of admission and discharge, as well as demographic information of the patient such as age, gender, and place of residence. The EMH employs a stratified two-stage sampling design, achieving near-universal coverage of hospital discharges (approximately 99.5%).

Our main outcome variable is derived focusing on heat-related discharges (HRDs), defined as discharges coded under ICD-9 code 992, which includes heat stroke and sunstroke (992.0), and various forms of heat exhaustion (992.3-992.5). We also restrict the data to working-age patients (aged 16-64), and define the variable y_{pym} as the count of HRDs occurring in province p and year-month ym. Our main outcome will be Y_{pym}, a dummy variable equal to 1 if there is at least one HRD in province p and year-month ym.

Climate Data A key object of interest in our analysis is the elasticity of HRDs with respect to the number of excessive heat days. We draw data on maximum temperature from the Spanish Temperature at Daily Scale (STEAD) dataset, which provides daily maximum and minimum temperature estimates on a 5km $\times$ 5km grid for peninsular Spain (1901–2014) and the Balearic and Canary Islands (1971–2014), based on data from over 5,500 meteorological stations [Serrano-Notivoli et al., 2019].[7]

To match our geographic and temporal units of analysis, we aggregate the data to the province-year-month level as follows. First, we assign each cell c to its municipality $muni$ based on its centroid. For each municipality, we compute the average daily maximum temperature across all cells it contains. We then aggregate to the province-day level using fixed municipal population weights from the year 2000, following Carleton et al. [2022]. Formally,

[7] STEAD employs an exhaustive quality control process and a novel reconstruction methodology that leverages all available station data—rather than relying only on long historical series—to fill gaps and interpolate temperature values. Local generalized linear mixed models are used to predict temperatures at each grid point and day, incorporating geographic features such as latitude, longitude, altitude, and distance to the coast.

the daily maximum temperature in province p on day d is:

$$T_{pd} = \sum_{muni \in p} \frac{pop_{muni}}{pop_p} \sum_{c \in muni} \frac{T_{cd}}{N^c_{muni}}$$

where T_{cd} is the maximum temperature in cell c on day d, N^c_{muni} is the number of cells in municipality $muni$ and pop_{muni}, pop_p are 2000 population in municipality $muni$ and province p, respectively. Finally, we compute the number of days on which the province-level temperature T_{pd} falls within one of eight predefined temperature intervals, each spanning 5°C, starting from 0°C, with an open-ended top bin for temperatures above 35°C. Our main climatic regressor is D^{35+}_{pym}, which denotes the number of days in year-month ym when the maximum temperature in province p falls into the top temperature bin (above 35°C). In our regression specification, we include indicators for all other temperature bins, using the 16-20°C bin as the omitted reference category.

Final Sample Our main dataset is a balanced panel of the 47 provinces of peninsular Spain observed over 144 months, from January 2000 to December 2011. We truncate the sample in 2011, as undocumented migrants were excluded from public healthcare access starting in 2012. We define the period from January 2000 to December 2004 as the pre-amnesty period, and January 2005 onward as the post-amnesty period. Table 1 presents summary statistics of the main variables.

4 Empirical Strategy

Our identification strategy leverages three distinct sources of variation. First, we exploit temporal variation by comparing outcomes before and after the implementation of the 2005 amnesty. Second, we use cross-provincial variation in exposure to the reform, proxied by the relative size of the undocumented migrant population—both overall and focusing on agricultural employment. Third, we exploit variation in temperature across provinces and over time, and examine whether the elasticity of HRDs to excessive heat exhibits a structural break after the reform, particularly in provinces more exposed to the policy. This motivates a triple-difference specification. Our design compares the average effect of an extra day above 35°C on heat-related hospitalizations in a high exposure province vs. a low exposure province, before and after the 2005 amnesty program.

Incorporating temperature and the incidence of excessive heat days as an additional source of variation allows us to address the main threats to identification that would arise in a simpler difference-in-differences framework comparing provinces with high versus low exposure to the reform over time. A key concern in such a setup is that provinces with larger undocumented populations may differ systematically from others along dimensions correlated with both the reform and health outcomes. By leveraging temperature shocks, we isolate differential impacts across provinces based on their exposure to heat stress, thereby strengthening the credibility of our identification strategy.

We implement the following regression specification

$$\begin{aligned} Y_{pym} = {} & \beta D^{35+}_{pym} \times HiUnd_p \times Post_{ym} + f(D^{35+}_{pym}, HiUnd_p, Post_{ym}) \\ & + \mathbf{X}'_{pym}\gamma + \mathbf{W}'_{pym}\theta + \mathbf{Z}'_{pym}\lambda + \eta_{pm} + \alpha_{ym} + u_{pym} \end{aligned} \tag{1}$$

where Y_{pym} is the binary indicator equal to one if any HRD is recorded in province p, year y and month m, D^{35+}_{pym} is the count of days in which the daily maximum temperature exceeded 35°C, $Post_{ym}$ is an indicator for the post-amnesty period (January 2005 onward) and $HiUnd_p$ is an indicator equal to 1 for provinces with above median share of undocumented migrant population. $f(\cdot)$ is a linear function of its arguments and their pairwise interactions. $\mathbf{X}_{pym}$ is a vector of climatic controls that includes count of days in the other temperature bins (see Section 3) and monthly precipitation, fully interacted with both the $Post_{ym}$ and $HiUnd_p$ variables. $\mathbf{W}_{pym}$ is a vector of province-level labor market controls measured before the amnesty that includes: log population (migrant and native) in 2003 and 2004, the unemployment rate, log of average wage, employment shares in agriculture, hospitality, and the public sector, the shares of part-time contracts and fixed-term contracts in 2004, and a coastal indicator, and their interactions with both $Post_{ym}$ and $HiUnd_p$. $\mathbf{Z}_{pym}$ is a vector of province-specific linear and quadratic trends, fully interacted with both $Post_{ym}$ and $HiUnd_p$. η_{pm} and α_{ym} are province-month and year-month fixed effects. Finally, u_{pym} captures any other residual determinant of the outcome variable of interest. We allow them to be correlated across observations belonging to the same province by clustering standard errors at that level.[8]

The coefficient of interest is β, which captures whether the elasticity of HRDs with respect to excessive heat exhibits a structural break following the amnesty, specifically in provinces more exposed to the policy relative to less exposed ones. The coefficient captures the effect of a bundled treatment: the offer of work permits to the undocumented population and an increase in labor inspections.

[8] In using this specification we follow the literature on climate and health [Barreca et al., 2016].

A potential concern with our identification strategy is that, following regularization, undocumented migrants may have become more willing to seek medical attention when affected by extreme heat. If this were the case, we would expect to observe a higher—not lower—elasticity of HRDs with respect to excessive heat in the post-reform period, particularly in provinces more exposed to the amnesty. In other words, any increase in healthcare-seeking behavior would bias our estimates toward finding a stronger response of hospitalizations to heat. This implies that our finding of a reduced elasticity likely reflects a lower bound on the true protective effect of the reform.[9] To address this point further we evaluate whether discharges unrelated to heat or working conditions were affected by the amnesty program. If undocumented migrants are more willing to seek medical attention after the amnesty program, we would expect more exposed provinces to see higher total admissions. Appendix Table A.1 shows the coefficients from a difference-in-difference design. The coefficient associated with the total number of discharges (excluding heat-related) is not significant.[10]

Another concern is that provinces with a larger relative size of undocumented migrant population may be different from others along other characteristics that are potentially correlated with the incidence of HRDs and their evolution over time. Our triple-difference approach partially addresses this concern, as variation along these other characteristics would need to correlate with changes in the elasticity of HRDs to excessive heat to invalidate our identification strategy. To address this point further, our preferred specification includes as regressors a vector $\mathbf{W}_{pym}$ of baseline province-level characteristics, fully interacted with both the $Post_{ym}$ (and $HiUnd_p$) dummy variables.

5 Results

Table 2 presents the OLS estimates of the parameters in Equation 1. The results indicate that the amnesty program causally reduced the elasticity of HRDs to extreme heat in provinces with a high share of undocumented migrants. Our preferred specification, shown in column 4, suggests that, following the amnesty, one additional day with a maximum temperature above 35°C is 3.3 percentage points less likely to cause any HRD. This represents a 9.4%

[9] There is also a related concern but that implies a bias in the opposite direction. If undocumented migrants become more willing to seek medical attention, they may become healthier overall and less prone to heat-strokes. However, in the adult non-elderly population, heat-strokes are overwhelmingly caused by strenuous physical activity under high outside temperatures. They are not related to pre-existing health conditions [Epstein and Yanovich, 2019]. Hence, access to better healthcare is unlikely to cause fewer HRDs.

[10] The coefficient associated with intoxications (Intox.) is negative and significant, while the coefficient associated with injuries (Inj.) is positive and marginally significant.

decline relative to the pre-amnesty mean of the outcome in months with at least one very hot day (mean = 0.351). This effect points to improved working conditions among migrant workers who gained legal status through the reform.

We begin by presenting the estimated coefficients from a simplified model with only province fixed effects (column 1). Because this specification does not account for time-varying shocks (such as seasonal variation in temperature), we expect to detect an association of extreme heat with HRDs. Reassuringly, we find that very hot days significantly increase the likelihood of a heat-related discharge. The triple interaction term, which captures the differential change in the association of heat and HRDs in high-exposure provinces after the reform, is negative and significant, consistent with our hypothesis.

In column 2, we add year-month fixed effects and pre-amnesty province-level controls. The triple interaction coefficient remains negative and significant, again consistent with our hypothesis. Unsurprisingly, the direct effect of extreme heat is muted. In column 3, we introduce province-month fixed effects as well as province-specific linear and quadratic trends. This is the full model of Equation 1. In this more demanding specification, the triple interaction coefficient remains negative, similar in magnitude, though significant at the 10% level.

Our preferred specification, shown in column 4, restricts the sample to the warm season (May-September). Under this specification, the estimated effect becomes larger in magnitude and statistically significant at the 5% level. As a robustness check, we also estimate a logit model including the full set of climatic and labor market controls, as well as province and year-month fixed effects. The coefficient on the triple interaction is negative and significant at the 5% level.

The coefficient on the interacted $D^{35+} \times Post$ variable is never significant, indicating that there is no detectable effect in provinces with a low share of undocumented migrants. The same is true for the coefficient on $Post \times HiUnd$, which suggests that a simple difference-in-difference design that does not exploit the variation in temperature would not be able to detect any effect on HRDs and therefore on working conditions.

In Table 3, we test the robustness of our results to different specifications and definitions of exposure. Column 1 reproduces the results of our main specification (column 4 in Table 2) for reference. In column 2 we replace the binary classification of provinces with a continuous measure of the share of undocumented migrants ($ShUndoc$). The estimated coefficient remains negative and significant. Because we expect most of the effects to be concentrated among workers who were previously undocumented and informally employed in agriculture, we also classify provinces using the estimated share of undocumented migrants in agriculture, $ShAgriUnd$ (see Section 3). Columns 3 and 4 present the results using this measure, in binary and continuous form, respectively. The estimates effects are of similar magnitudes and, if anything, slightly more precisely estimated.

In column 5, we show that our estimates are robust to omitting the provinces of Barcelona and Madrid. These are the two major urban areas in Spain, host a large migrant population, but have relatively small agricultural sectors. In columns 6 and 7, we estimate our coefficient separately by gender of the patient. The outcome variable are therefore Y^{male}_{pym}, which is an indicator equal to 1 if there is at least one discharge of a male patient aged 16-64 in province p during year-month ym, and Y^{fem}_{pym}, which is the equivalent for female patients. Although results do not look statistically different by gender, the magnitude of the coefficient is roughly four times larger for male patients than it is for female patients. This is to be expected since most migrant workers in agriculture are men.

Figure 2 provides a graphical representation of the results. We estimate the elasticity of HRDs to temperature separately for each of the four groups defined by the difference-in-differences design, and plot the coefficient associated with each temperature bin. The Figure provides several insights that corroborate our interpretation of the regression results. First, the coefficients on temperature bins lower than 25°C are small and not statistically significant. Second, and as expected, they are only significant starting from the 26-30°C bin and only in provinces with a high share of undocumented migrants in agriculture. Third, and most importantly, the figure clearly shows the decline in the elasticity of HRDs to extreme heat in provinces with a high share of undocumented migrants in agriculture: the estimated elasticity is 0.060 (95% CI: 0.024, 0.096) in the pre-amnesty period (2000-2004) and 0.016 (95% CI: -0.006, 0.037) in the post-amnesty period (2005-2011). In contrast, the elasticity in low-exposure provinces is not distinguishable from zero in either periods. Results are similar when classifying provinces using the share of undocumented migrants, as shown in Appendix Figure A.3.

Mechanisms We document a large and robust decline in heat-related hospitalizations following days with extreme heat, driven by a large decline in provinces with a large pre-amnesty population of undocumented migrants. We hypothesize that this reduction is driven by improved working conditions. As migrant workers gain access to the amenities associated with formal contracts, their bargaining power increases due to a larger set of outside options. While improvements within a sector are difficult to measure, this enhanced bargaining power should also be reflected in a greater ability for migrants to switch to sectors with better conditions. Therefore, evidence of increased sector-switching would support this outside option channel.

Consistent with this hypothesis, we find that the amnesty prompted migrants to transition from agriculture, a sector known for poor conditions, toward construction. Figure 3 presents the primary evidence for this mechanism. Panel (a) displays the results from a dynamic difference-in-differences specification. We compare provinces with a high pre-amnesty share of undocumented migrants to those with a low share, before and after the program, controlling for province-by-quarter and year-by-quarter fixed effects.[11] The reform led to a 4-percentage-point decrease in the agricultural share of migrant employment and a corresponding 5-percentage-point increase in the construction share. In contrast, we find no such employment shifts for native workers. These results are confirmed in a static difference-in-differences specification, with results shown in Appendix Tables A.5 and A.6.

To further test this mechanism, we track the subsequent careers of regularized migrants and find a clear movement away from agriculture towards better opportunities. Panels (b) and (d) of Figure 3 track the careers of migrants who were regularized in the agriculture and construction sectors, respectively. A migrant is considered "regularized" in a given sector if their first formal contract recorded in the Spanish Social Security system appeared during the amnesty window in that sector [Elias et al., 2025]. The two panels show starkly different retention rates. Migrants regularized in agriculture were quick to leave the sector; after two years, only 30.4% remained, while 24% had moved to construction. In contrast, 66% of those regularized in construction remained in that sector, and virtually none had switched to agriculture.

Robustness and Placebo Estimates We implement a series of checks to verify the validity of our results. Appendix Table A.2 shows that our findings are robust to excluding observations pertaining to the five months during which the amnesty program was unfolding, that is from January 2005 to May 2005. Appendix Table A.3 shows that results are qualitatively and quantitatively similar when classifying provinces using the share of undocumented migrants from non-EU countries. Results are also robust to excluding one year at a time and one province at a time, as shown in Figures A.5 and A.4, respectively. We also run a placebo test by replacing the outcome of the model in Equation 1 with discharges that should not be affected by heat shocks and by the amnesty program. As shown in Appendix Table A.4, the estimated triple interaction coefficients are small and statistically insignificant.

[11] For this exercise, our panel has a quarterly frequency due to the availability of the Spanish Labor Force Survey.

6 Conclusions

This paper provides novel evidence that granting legal status to undocumented migrants reduces exposure to labor exploitation. We study Spain's 2005 amnesty program, which offered legal work permits to approximately 600,000 undocumented migrants, and evaluate its impact on working conditions using administrative health records, climate data, and residency and work permit records. Our identification strategy exploits variation in reform exposure across provinces, timing of the policy, and exogenous fluctuations in temperature. We proxy extreme labor exploitation using heat-related discharges among working-age individuals on very hot days, a measure grounded in the occupational risks faced by outdoor workers in agriculture and construction.

We find that the elasticity of heat-related hospital discharges (HRDs) to very hot days declined significantly after the reform in provinces with a high share of undocumented migrants. In our preferred specification, one additional day above 35°C is associated with a 3.3 percentage point reduction in the probability of observing any HRD, an effect that represents a 9.4% decline relative to the pre-amnesty baseline. These results are robust to a variety of robustness checks and placebo tests. Moreover, the effect is concentrated among provinces with a high share of undocumented migrants in agriculture, and is notably larger among male patients, consistent with the demographic composition of the migrant agricultural workforce. We show that the effect is driven by reallocation of jobs from agriculture, a sector with notoriously bad working conditions, to other sectors, mainly construction.

Together, our findings indicate that regularization policies can mitigate labor exploitation by reshaping incentives in the labor market. Granting legal status improves migrants' access to formal employment, enabling them to leave the most hazardous jobs. Importantly, the decline in heat-related hospitalizations following the amnesty is not offset by increases among other groups, suggesting that the reform generated a net improvement in job quality rather than a mere reallocation of dangerous tasks. As migration pressures persist and informality remains widespread, expanding legal protections for undocumented workers may provide a meaningful path to improving workplace safety and reducing exploitation. Furthermore, in the context of rising global temperatures and more frequent extreme weather events, our results underscore the public health relevance of labor market institutions, highlighting that the relationship between heat exposure and morbidity depends critically on working conditions.

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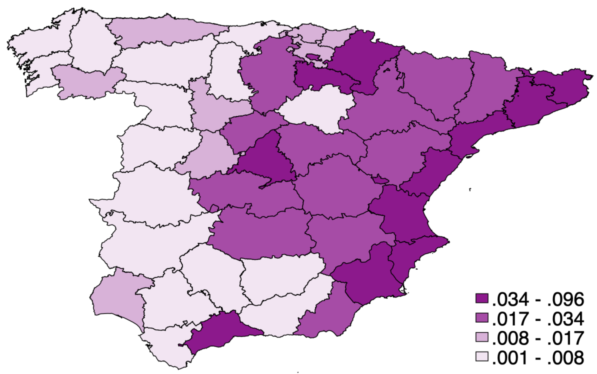
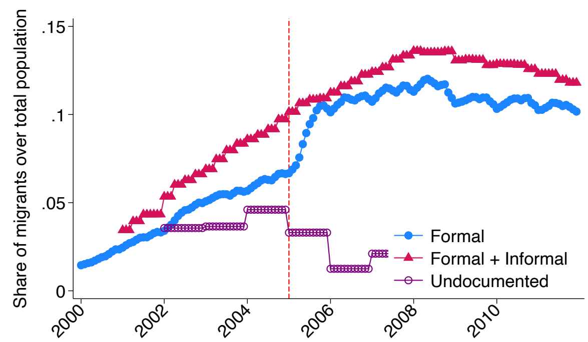
Exhibits

Figure 1: Amnesty program descriptives



(a) Share Undocumented: 2004



(b) Evolution of migrants

Note: Panel (a) presents the distribution of the share of undocumented migrants across Spanish Provinces in 2004, the year before the amnesty program. The share of undocumented migrants is calculated by dividing the number of undocumented migrants by the number of inhabitants. For details see Section 3. Panel (b) plots the evolution of the share of migrants over total number of workers in the Labor Force Survey (red line) and in the Social Security Records (blue line). The purple line presents the share of undocumented migrants over total population. Back to Section 2.

Table 1: Summary statistics of the main variables

	Mean	S.d.	Min	Max	Obs.
Heat-related discharge dummy, Y_{pym}	0.116	0.321	0.000	1.000	6768
Heat-related discharge, y_{pym}	0.196	0.726	0.000	12.803	6768
Extreme heat days, $D_{pym}^{>35}$	0.513	2.350	0.000	24.000	6768
Population 2004 (Million)	0.855	1.081	0.092	5.805	6768
Immigrant share 2004	0.051	0.036	0.013	0.157	6768
Non-EU share 2004	0.042	0.028	0.010	0.104	6768
Share undocumented, $ShUndoc_p$	0.022	0.019	0.001	0.096	6768
Share undocumented in agriculture, $ShAgriUndoc_p$	0.002	0.004	0.000	0.024	6768

Note: the sample is a balanced monthly panel comprising of the 47 provinces of peninsular Spain, observed from January 2000 to December 2011 for a total of 144 months. Back to Section 3.

Table 2: Main estimates

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) Logit
$D^{>35}_{pym}$	0.020***	0.002	0.009	0.012	0.081
	(0.006)	(0.007)	(0.011)	(0.015)	(0.057)
$D^{>35}_{pym}$ × Post	0.005	0.010	0.010	-0.001	0.051
	(0.006)	(0.007)	(0.008)	(0.014)	(0.075)
Post × HiUnd	0.005	-3.961	24.379	-7.189	-33.053
	(0.038)	(2.395)	(29.956)	(60.243)	(38.027)
$D^{>35}_{pym}$ × Post × HiUnd	-0.022**	-0.024**	-0.022*	-0.033**	-0.179**
	(0.011)	(0.011)	(0.012)	(0.016)	(0.079)
Year × Month FE		✓	✓	✓	✓
Prov × Month FE			✓	✓	
Full Controls		✓	✓	✓	✓
Linear + Quadratic trends			✓	✓	
May-Sep only				✓	
R2	0.256	0.301	0.403	0.389	
Pseudo R2					0.333
Obs.	6768	6768	6768	2820	5106

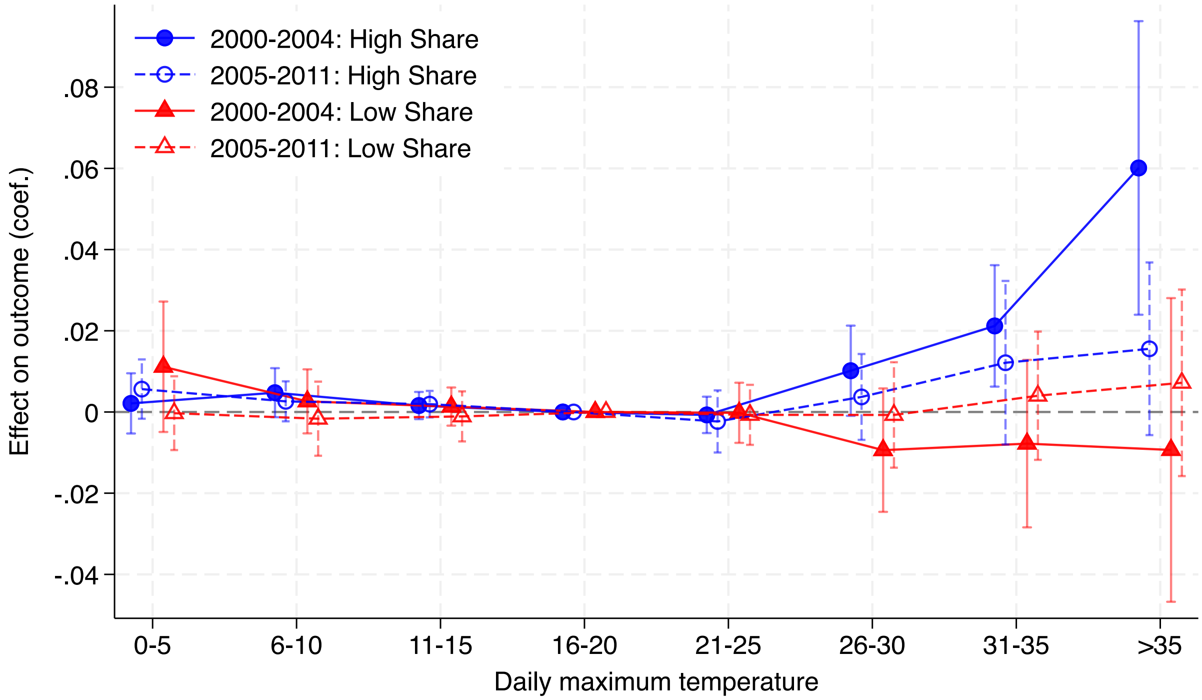
Note: controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Table 3: Robustness estimates

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) No Mad,Bcn	(6) Men	(7) Women
$D_{pym}^{>35}$ × Post × HiUnd	-0.033**				-0.035**	-0.016	-0.004
	(0.016)				(0.016)	(0.021)	(0.016)
$D_{pym}^{>35}$ × Post × $ShUndoc_p$		-1.166**					
		(0.462)					
$D_{pym}^{>35}$ × Post × HiAgriUndoc			-0.033**				
			(0.015)				
$D_{pym}^{>35}$ × Post × ShareAgriUnd				-7.646***			
				(2.676)			
Year × Month FE	✓	✓	✓	✓	✓	✓	✓
Prov × Month FE	✓	✓	✓	✓	✓	✓	✓
Full Controls	✓	✓	✓	✓	✓	✓	✓
Linear + Quadratic trends	✓	✓	✓	✓	✓	✓	✓
May-Sep only	✓	✓	✓	✓	✓	✓	✓
R2	0.389	0.392	0.390	0.390	0.374	0.372	0.261
Obs.	2820	2820	2820	2820	2700	2820	2820

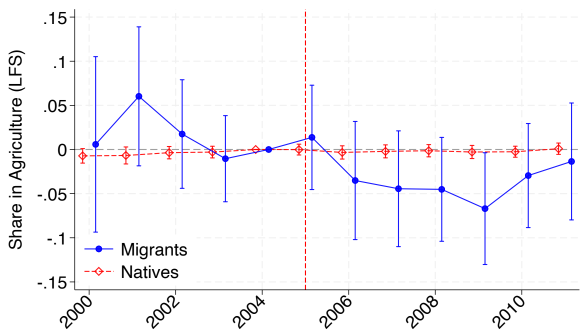
Note: controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Figure 2: Estimated relationship between maximum temperature and heat-related discharges

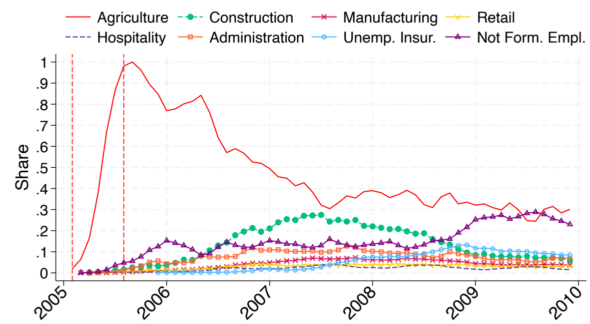


Note: Each specification controls for province-month and year-month FE, province-specific linear and quadratic trends and monthly precipitations. The blue solid dots show coefficients estimated using data for the pre-amnesty period (2000-2004) and provinces with an above-median share of undocumented migrants in agriculture over total population. The blue hollow dots show coefficients estimated using data for the post-amnesty period (2005-2011) and provinces with an above-median share of undocumented migrants in agriculture over total population. The red solid triangles show coefficients estimated using data for the pre-amnesty period (2000-2004) and provinces with a below-median share of undocumented migrants in agriculture over total population. The red hollow triangles show coefficients estimated using data for the post-amnesty period (2005-2011) and provinces with an below-median share of undocumented migrants in agriculture over total population. Capped spikes show 95% confidence intervals. Standard errors are clustered at the province level. Back to Section 5

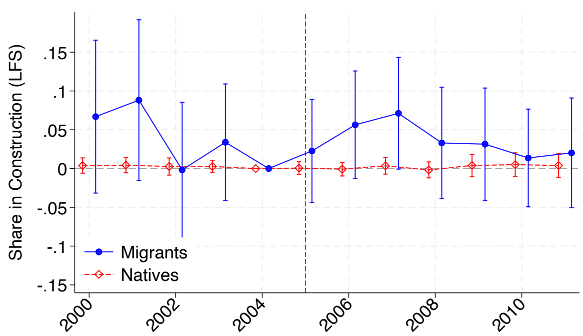
Figure 3: Mechanisms



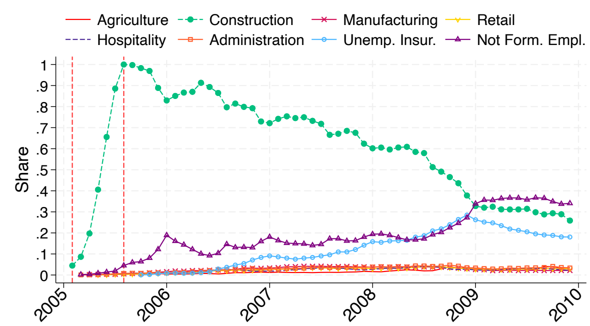
(a) Dynamic DiD on the agricultural share



(b) Regularized migrants in agriculture



(c) Dynamic DiD on the construction share

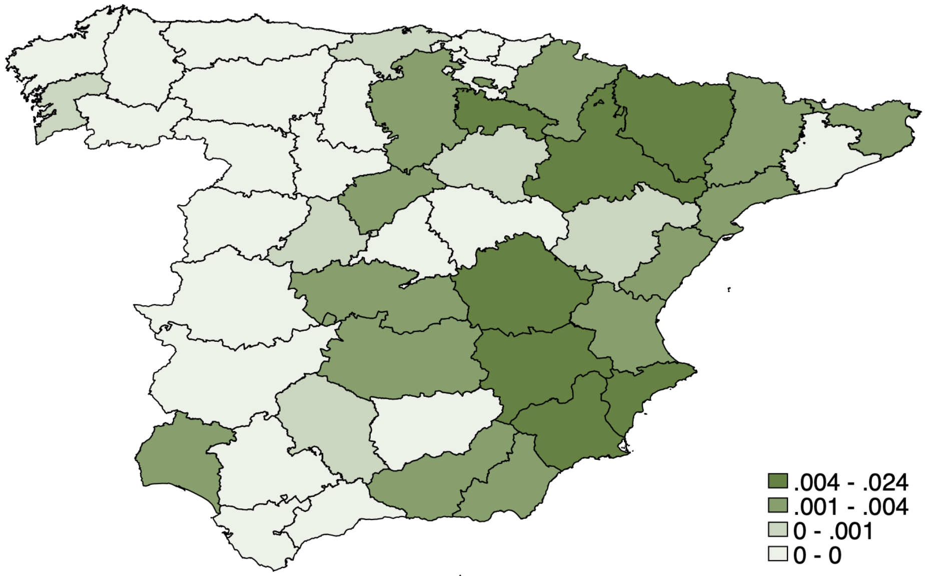


(d) Regularized migrants in construction

Note: Panel (a) and Panel (c) show estimated coefficients for a dynamic difference-in-difference specification with the agricultural share and construction share of employment, respectively, for migrants (blue solid dot) and natives (red hollow dot). The shares are computed using the quarterly Spanish Labor Force Survey. Panels (b) and (d) show the sectoral employment share of migrants that first entered Social Security records during the amnesty window in agriculture and construction, respectively. These are computed using the *Muestra Continua de Vidas Laborales* (MCVL) dataset from the Spanish Social Security administration.

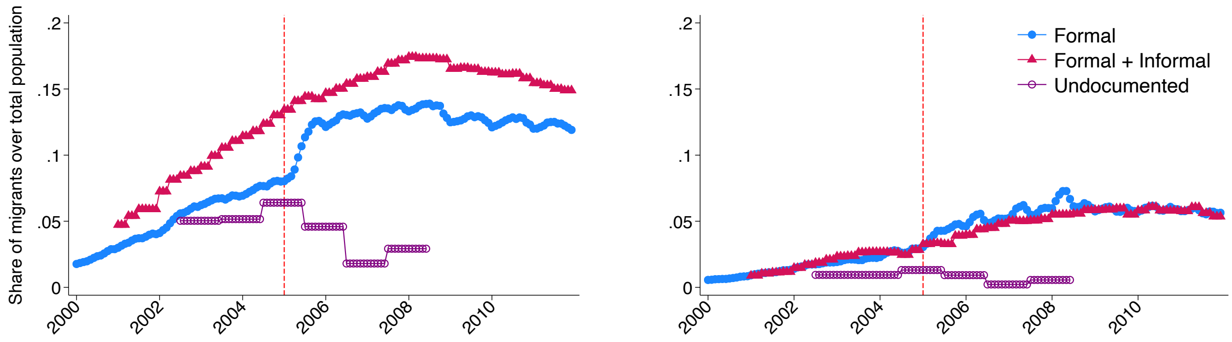
Appendix (For Online Publication)

Figure A.1: Distribution of the undocumented share in agriculture



Note: This figure presents the geographical distribution of the share of undocumented migrants in agriculture across Spanish Provinces in 2004, the year before the amnesty program. The share of undocumented migrants in agriculture is calculated by multiplying the number of undocumented migrants by the share of migrants employed in agriculture and then dividing by the number of inhabitants. For details see Section 3.

Figure A.2: Amnesty program descriptives by share of undocumented migrants



(a) High Share Undocumented: 2004

(b) Low Share Undocumented: 2004

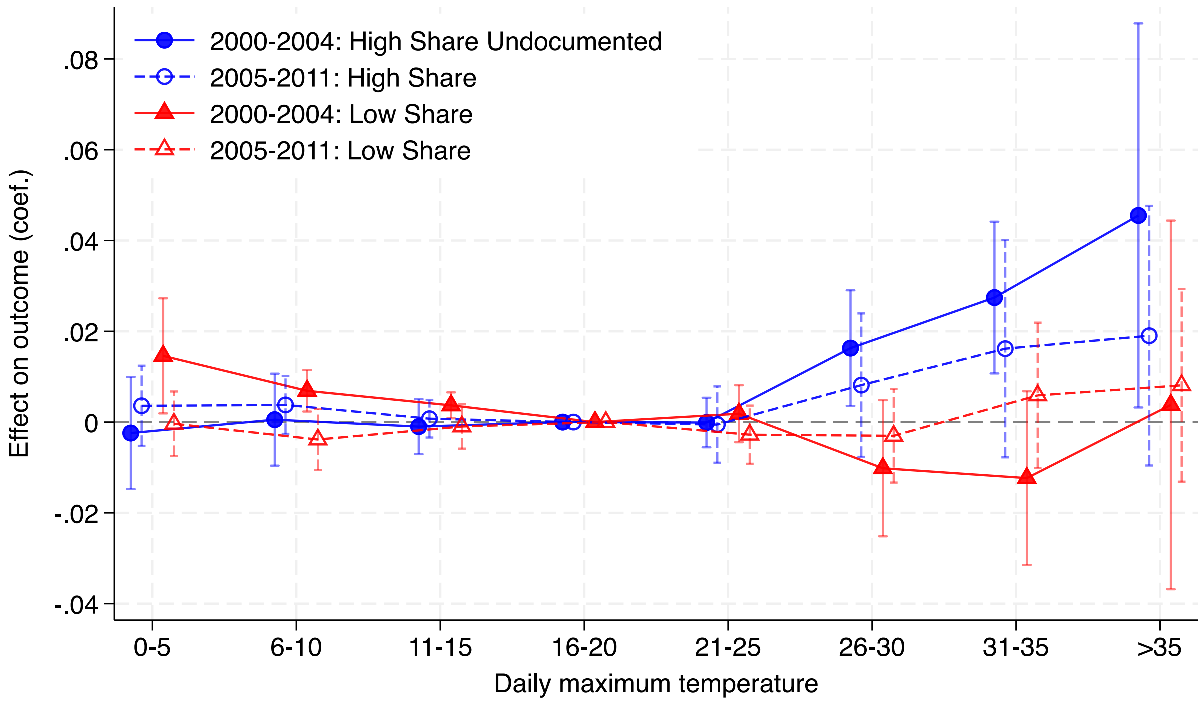
Note: This figure plots the evolution of the share of migrants over total number of workers in the Labor Force Survey (red line) and in the Social Security Records (blue line) and the share of undocumented migrants over total population (purple line), separately by high-exposure provinces (Panel (a)) and low-exposure provinces (Panel (b)). Return to Section 2.

Table A.1: Difference-in-differences estimates using outcomes (in asinh)

	(1) Heat	(2) Cardio	(3) Resp.	(4) G.u.	(5) Inj.	(6) Intox.	(7) Total
Post × HiUnd	-0.001	0.023	-0.014	-0.012	0.189*	-0.419**	0.017
	(0.040)	(0.048)	(0.039)	(0.046)	(0.112)	(0.190)	(0.024)
Year × Month FE	✓	✓	✓	✓	✓	✓	✓
Prov × Month FE	✓	✓	✓	✓	✓	✓	✓
Full Controls	✓	✓	✓	✓	✓	✓	✓
Linear + Quadratic trends	✓	✓	✓	✓	✓	✓	✓
R2	0.438	0.979	0.977	0.977	0.967	0.768	0.997
Obs.	6768	6768	6768	6768	6768	6768	6768

Note: outcomes are discharges whose primary diagnosis is heat-related (Heat), cardiovascular (Cardio), respiratory (Resp.), genitourinary (G.u.), injuries (Inj.), intoxication (Intox.), and total (excluding heat-related). Each outcome is the inverse hyperbolic sine transformation of the count of discharges. Controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Figure A.3: Estimated relationship between maximum temperature and heat-related discharges, using the undocumented share



Note: Each specification controls for province-month and year-month FE, province-specific linear and quadratic trends and monthly precipitations. The blue solid dots show coefficients estimated using data for the pre-amnesty period (2000-2004) and provinces with an above-median share of undocumented migrants over total population. The blue hollow dots show coefficients estimated using data for the post-amnesty period (2005-2011) and provinces with an above-median share of undocumented migrants over total population. The red solid triangles show coefficients estimated using data for the pre-amnesty period (2000-2004) and provinces with a below-median share of undocumented migrants over total population. The red hollow triangles show coefficients estimated using data for the post-amnesty period (2005-2011) and provinces with an below-median share of undocumented migrants over total population. Capped spikes show 95% confidence intervals. Standard errors are clustered at the province level. Return to Section 2.

Table A.2: Main results excluding January to May 2005

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) Logit
$D_{pym}^{>35}$	0.020***	0.002	0.010	0.014	0.081
	(0.006)	(0.007)	(0.011)	(0.015)	(0.057)
$D_{pym}^{>35}$ × Post	0.005	0.010	0.011	-0.003	0.060
	(0.006)	(0.007)	(0.008)	(0.014)	(0.075)
Post × HiUnd	0.010	-4.556**	19.415	23.486	-37.720
	(0.038)	(2.152)	(34.076)	(51.779)	(36.720)
$D_{pym}^{>35}$ × Post × HiUnd	-0.022**	-0.023**	-0.022*	-0.030*	-0.182**
	(0.011)	(0.011)	(0.012)	(0.017)	(0.078)
Year × Month FE		✓	✓	✓	✓
Prov × Month FE			✓	✓	
Full Controls		✓	✓	✓	✓
Linear + Quadratic trends			✓	✓	
May-Sep only				✓	
R2	0.258	0.303	0.405	0.390	
Pseudo R2					0.334
Obs.	6533	6533	6533	2773	4968

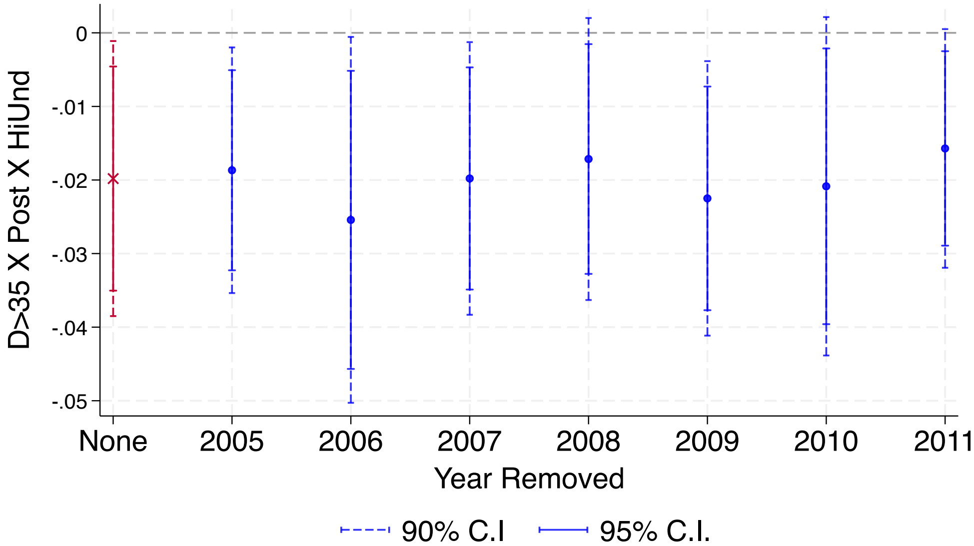
Note: controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Table A.3: Main results using the share of undocumented non-EU migrants

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) Logit
$D_{pym}^{>35}$	0.020***	0.002	0.010	0.016	0.004	0.089
	(0.006)	(0.007)	(0.011)	(0.015)	(0.015)	(0.055)
$D_{pym}^{>35}$ × Post	0.005	0.010	0.010	-0.006	0.003	0.024
	(0.006)	(0.007)	(0.008)	(0.014)	(0.014)	(0.070)
Post × HiUnd (NonEU)	-0.009	-3.637	17.636	-14.237		-29.650
	(0.038)	(2.373)	(31.970)	(59.044)		(38.262)
$D_{pym}^{>35}$ × Post × HiUnd (NonEU)	-0.021*	-0.023**	-0.022*	-0.028		-0.166**
	(0.011)	(0.011)	(0.012)	(0.017)		(0.077)
$D_{pym}^{>35}$ × Post × ShareUnd (NonEU)					-1.304**	
					(0.541)	
Year × Month FE		✓	✓	✓	✓	✓
Prov × Month FE			✓	✓	✓	
Full Controls		✓	✓	✓	✓	✓
Linear + Quadratic trends			✓	✓	✓	
May-Sep only				✓	✓	
R2	0.256	0.300	0.402	0.389	0.392	
Pseudo R2						0.333
Obs.	6768	6768	6768	2820	2820	5106

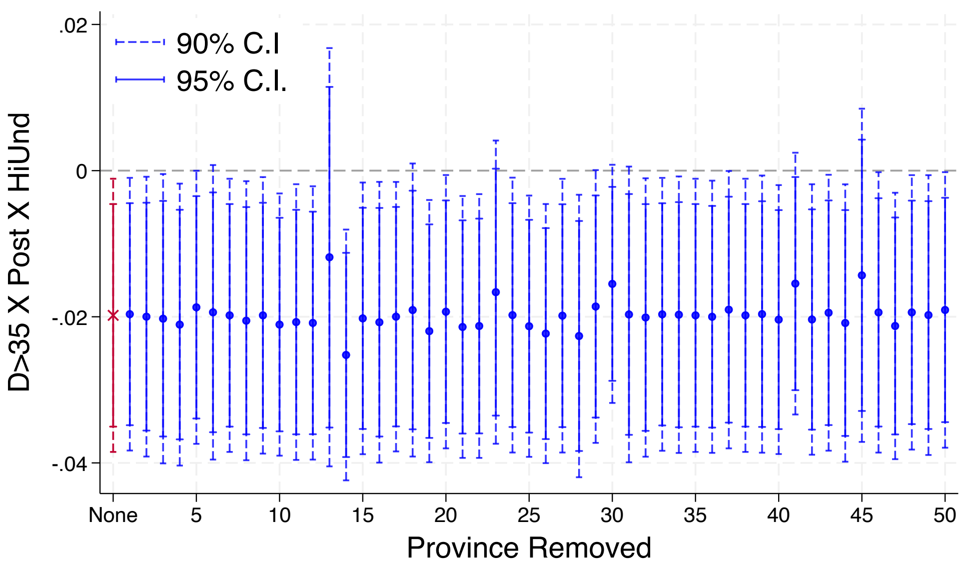
Note: controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Figure A.4: Main estimates, leave out one year



Note: This figure shows how the estimated triple interaction coefficient varies when sequentially excluding each post-reform year from the sample. The red cross point estimate is the baseline. Estimates remains consistently negative and statistically significant across all exclusions, indicating that the main result is not driven by any single year.

Figure A.5: Main estimates, leave out one province



Note: This figure shows the sensitivity of the estimated triple interaction coefficient to the exclusion of individual provinces. The red cross point estimate is the baseline. Each point represents the coefficient from the main regression when excluding one province.

Table A.4: Triple interaction coefficient using placebo outcomes (in asinh)

	(1) Heat	(2) Cardio	(3) Resp.	(4) G.u.	(5) Inj.	(6) Intox.	(7) Total
$D_{pym}^{>35}$	0.033	0.008	-0.013*	-0.004	0.008	0.046*	0.002
	(0.022)	(0.006)	(0.007)	(0.006)	(0.007)	(0.023)	(0.003)
$D_{pym}^{>35}$ × Post	-0.017	-0.008	0.013	0.004	-0.014*	-0.060***	0.001
	(0.018)	(0.005)	(0.009)	(0.007)	(0.008)	(0.022)	(0.002)
$D_{pym}^{>35}$ × Post × HiUnd	-0.026	0.003	-0.010	-0.005	0.001	0.024	-0.001
	(0.022)	(0.005)	(0.009)	(0.007)	(0.006)	(0.023)	(0.002)
Year × Month FE	✓	✓	✓	✓	✓	✓	✓
Prov × Month FE	✓	✓	✓	✓	✓	✓	✓
Full Controls	✓	✓	✓	✓	✓	✓	✓
Linear + Quadratic trends	✓	✓	✓	✓	✓	✓	✓
May-Sep only	✓	✓	✓	✓	✓	✓	✓
Mean DV	0.130	5.575	5.714	5.704	5.797	2.202	8.455
R2	0.452	0.985	0.977	0.981	0.977	0.797	0.998
Obs.	2820	2820	2820	2820	2820	2820	2820

Note: outcomes are discharges whose primary diagnosis is heat-related (Heat), cardiovascular (Cardio), respiratory (Resp.), genitourinary (G.u.), injuries (Inj.), intoxication (Intox.), and total (excluding heat-related). Each outcome is the inverse hyperbolic sine transformation of the count of discharges. Controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Table A.5: Difference-in-differences estimates on the agricultural share

	Natives			Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)
Post × HiUnd	0.002	-0.006	-0.003	-0.045**	-0.048	0.005
	(0.004)	(0.004)	(0.005)	(0.021)	(0.035)	(0.067)
Year × Quarter FE	✓	✓	✓	✓	✓	✓
Prov × Quarter FE	✓	✓	✓	✓	✓	✓
Full Controls		✓	✓		✓	✓
Linear + Quadratic trends			✓			✓
R2	0.905	0.925	0.946	0.503	0.519	0.631
Obs.	2256	2256	2256	2211	2211	2211

Note: outcomes are shares of workers employed in agriculture (by group) over the total number of employees in that group: natives (Natives) and all migrants (Migrants). Controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.

Table A.6: Difference-in-differences estimates on the construction share

	Natives			Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)
Post × HiUnd	-0.001	-0.001	0.000	0.000	0.052	0.206***
	(0.004)	(0.007)	(0.010)	(0.022)	(0.032)	(0.046)
Year × Quarter FE	✓	✓	✓	✓	✓	✓
Prov × Quarter FE	✓	✓	✓	✓	✓	✓
Full Controls		✓	✓		✓	✓
Linear + Quadratic trends			✓			✓
R2	0.818	0.835	0.895	0.321	0.347	0.473
Obs.	2256	2256	2256	2211	2211	2211

Note: outcomes are shares of workers employed in construction (by group) over the total number of employees in that group: natives (Natives) and all migrants (Migrants). Controls include population (total and migrant) in 2003 and 2004, unemployment rate, employment in part-time, permanent, public, agricultural and hospitality jobs, average wage, days worked in 2004 and a coastal dummy. Standard errors are clustered at the province level. Back to Section 5.