Immigration Enforcement and Food Safety:

Evidence from US Meat and Poultry Processing Plants

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ABSTRACT

Immigrant labor constitutes a substantial portion of the US meat and poultry processing workforce. However, the downstream effects of deportations targeting these immigrants on their food safety practices remain largely unexamined. We provide novel empirical evidence that increased deportations of undocumented immigrants are associated with a rise in food safety inspection violations, suggestive of reduced food safety quality at these establishments. We also find evidence that wages and labor market dynamics adjust in ways consistent with labor shortages following deportations, marked by increases in wages, hires, separations, and employment, along with a modest reduction in turnover. By examining the potential downstream food safety risks associated with deportations, this research contributes to the broader policy discussion about the spillover effects of immigration enforcement on food safety and consumer welfare.

Keywords: immigrants, deportations, labor shortages, inspection violations

1. INTRODUCTION

Immigrant workers comprise almost 33% of the US meat processing labor force (Migration Policy Institute, 2020). Workers in this industry perform essential labor-intensive tasks such as slaughtering, deboning, trimming, processing, inspection, and packaging (Alexander, 2012; BLS, 2021). The industry's heavy reliance on immigrant labor, many of whom are employed in these essential and specialized roles, makes it vulnerable to workforce disruptions. Specifically, worksite raids and deportations have increased hiring, separations, and worker turnover while reducing labor productivity in the animal slaughtering and processing industry (Orrenius and Zavodny, 2022). As workers play a crucial role in maintaining operational and food safety standards in these

industries (Alexander, 2012), worker absences and replacements can lead to operational inefficiencies and increase the risk of food safety inspection violations. Inspection violations can have significant downstream effects, affecting the product's safety and consumer welfare. Although literature indicates that food safety is a primary concern confronting meat processors, there is little research examining how deportation fear, labor shortages, and worker replacements can affect food safety quality. We use the actual number of deportations between 2004 and 2019 to assess the impact of this negative shock to the immigrant labor supply on meat and poultry processing operations and the resulting food safety quality.

Historically, immigrant labor in the meat industry has improved consumer welfare through lower retail meat prices and greater availability of meat products. Thereby, Krumel (2017) has cautioned policymakers against hasty immigration reforms by arguing that reducing immigrant workers could decrease overall economic welfare by increasing labor costs and meat prices. However, food safety, a key non-financial aspect of consumer welfare, remains largely unexamined in the immigration enforcement literature. This research fills this gap in the literature by investigating the meat and poultry processing industry, where labor disruptions don't just impact employment; they fundamentally alter workflow efficiency, production consistency, and compliance with food safety standards. Specifically, I examine how deportations, a measure of federal immigration enforcement, affect workforce stability, processing operations, and food safety, connecting policy impacts to critical health risks and broader public welfare consequences.

The meat and poultry processing industries are ideal to evaluate the impact of deportations on food safety and consumer welfare. First, because meat is a dietary staple and can affect the well-being of Americans. CDC estimates 1 in 6 Americans (or 48 million) get sick, and 3,000 die from foodborne illnesses each year in the United States (CDC, 2018), with 29% of deaths attributed to

contaminated meat and poultry (Painter et. al., 2013). Second, this industry is known to hire a large share of immigrant workers, with nearly 82,700 workers being undocumented (Svajlenka, 2021). Deportations of undocumented immigrants can reduce their labor force participation and employment (Ameudo-Dorantes & Antman, 2021), along with chilling effects on legal immigrants and natives, reshaping workforce dynamics across these industries (East et al., 2023; Orrenius & Zavodny, 2024). By examining the relationship between deportations, labor force dynamics, and food safety, this research aims to develop informed strategies that mitigate operational disruptions, sustain industry competitiveness, and ensure the integrity of food processing standards amidst evolving labor challenges in the meat and poultry processing industries.

Immigration raids, frequently covered by the media, also shape public perceptions of immigration enforcement actions, influencing the behavior of immigrant workers and broader communities (Maurer, 2023). With the new administration taking office in January 2025, immigration enforcement has intensified with ICE planning to detain and deport 600 to 1,000 immigrants a day, living in the US without legal authorization (Pedraza et al., 2025). This has fueled widespread public concern, as evidenced by a surge in Google searches for terms like "U.S. Immigration and Customs Enforcement," "ICE," and "What is ICE," reaching their highest levels since 2004 (Cat, 2025). Immigrant workers may experience increased stress, which could lead to increased work absences or reduced morale and productivity at work (McGlauflin, 2025; Offidani-Bertrand, 2023; Oliveira et al., 2022). This cycle of media coverage, public engagement, and behavioral adaptation underscores the powerful role of information accessibility in shaping responses to immigration enforcement. Therefore, we also examine the dynamics of fear and awareness as they spread through social networks, influencing the behavior in this context. We utilize search intensity for immigration raid-related terms in Google Trends from 2004 to 2019 to generate a Google Trends

index as a proxy for perceived awareness and fear of immigration raids among immigrant populations.

Our primary analysis measures whether the increase in deportations of immigrant populations, along with heightened awareness of immigration raids, affects the safety of food from US meat and poultry processing establishments. We assess food safety using the meat and poultry inspection (MPI) reports of the USDA Food Safety Inspection Services (FSIS) inspected meat and poultry processing establishments. MPIs are conducted daily and at least once per operating shift at these establishments to ensure adherence to FSIS food safety regulations to prevent adulterated products from entering commerce and reduce the risk of foodborne illnesses. Inspections include but are not limited to, reviews of the establishment's records, reviews of the establishment's validated Hazard Analysis and Critical Control Point (HACCP) plans (e.g., checking product temperatures at specified points during processing), and evaluations of whether the sanitary conditions of the processing areas meet standards outlined in Sanitation Standard Operating Procedures (SSOPs) both before and during processing operations (e.g., cleanliness of processing equipment and operating area). The violation rates of these inspections, therefore, reflect the food safety level of the establishments, with higher rates of inspection violations indicating declining compliance with food safety regulations and a more negative impact on public health (USDA-FSIS, 2023).

Using inspection task reports of near universe of 6000 federally inspected meat and poultry processing establishments observed in any given year across 47 contiguous US states and the District of Columbia from 2004-2019, we constructed four outcomes of interest that include the MPI violations rate for HACCP, pre-operational SSOP, operational SSOP, and sanitation inspections. We combine FSIS data on MPI violation rates with Transactional Records Access

Clearinghouse (TRAC) data on Immigration and Customs Enforcement (ICE) deportations and Google Trends (GT) data on awareness of immigration raids. These unique datasets will help establish a link between federal immigration enforcement priorities and food safety at meat and poultry processing establishments. We hypothesize that increased deportations of undocumented immigrants, along with heightened awareness of immigration raids, can compromise food safety compliance standards at meat and poultry processing establishments by disrupting worker dynamics and behavior, and reducing productivity.

We find that an increase in deportations increases the meat and poultry inspection violations. Specifically, an additional 1000 deportations in a given month in a given state significantly raises the HACCP inspection violations rate by 0.03%, pre-operational SSOP inspection violations rate by 0.03%, operational SSOP inspection violations rate by 0.009%, and the sanitation inspection violations rate by 0.02% across all the establishments in that month and state. Deportations can thus compromise core food safety operations at meat and poultry processing establishments and have huge public health significance.

Several findings suggest a causal link. First, our preferred panel fixed effects specification includes a full set of establishment and month-year fixed effects, along with broad economic controls, such as state-level annual population estimates, annual unemployment rates, and establishment-level time-varying inspection characteristics, including the total number of inspections. The results remain robust even when these controls are excluded. Second, findings from our distributed lag model indicate that MPI violation rates do not exhibit significant trends in the evolution of MPI violation rates before deportations.

We next examine the mechanisms that establish the link between deportations, labor market dynamics, and meat and poultry inspection violations. Using QWI data, we find that worker

separations increase by 0.20% for every 10% rise in deportations, consistent with the labor shortage that follows these deportations. This situation prompts employers in the meat and poultry processing sector to temporarily raise wages to replace the workers necessary for ongoing operations, as evidenced by the wage increases in CPS-ORG data. Our findings suggest that a 10% increase in deportations is associated with a 0.30% rise in hourly wages and a 0.30% increase in weekly wages for meat and poultry processing workers. Additionally, we provide empirical evidence that a 10% increase in deportations boosts employment by 0.16% and hiring by 0.19%, while reducing turnover by 0.08%, reflecting patterns of worker replacement. This suggests that the meat and poultry processing industry can and does adjust to inward shocks in labor supply by increasing hiring and wages.

A growing body of literature has analyzed the spillover effects of immigration enforcement on consumer welfare, often focusing on economic disruption and social vulnerabilities. Howard et al. (2024), for example, examined the construction industry and identified reduced housing supply and increased home prices due to labor shortages induced by deportations. Similarly, deportations have reduced participation in federal safety net programs among mixed-status households, such as the Supplemental Nutrition Assistance Program (SNAP), Supplemental Security Income (SSI), and Medicaid, worsening their health and financial stability (Alsan & Yang, 2022; Watson, 2014). We contribute by providing novel empirical evidence on how deportations can decrease consumer welfare, as measured by the rate of meat and poultry inspection violations in the meat and poultry processing industry.

Our findings also contribute to the broader literature on immigration enforcement in several ways. First, it focuses exclusively on actual deportations, unlike previous studies that have emphasized de jure immigration policies such as 287(g) and the Secure Communities Program (East et al.,

2023; Howard et al., 2024; Alsan & Yang, 2022), except for a few (Ameudo-Dorantes & Antman, 2021). While immigration policies can vary in enforcement and implementation, deportations provide tangible outcomes of these policies, making them a valuable measure for assessing the real-world impacts of federal immigration enforcement measures. Second, it examines the industrial food safety outcomes in the meat and poultry processing industry—a chilling effect of a different nature with significant policy implications for public health and consumer welfare. Third, the period from 2004 to 2019 offers a valuable perspective for analyzing the impact of immigration enforcement, as this timeframe captures shifts in enforcement practices and deportation priorities under three presidential administrations: Bush (2004-2009), Obama (2009-2017), and Trump (2017-2019). Fourth, we also evaluate if awareness and fear can spread through social networks, affecting the workplace behavior of immigrants and impacting food safety.

Our findings also contribute to the broader food safety literature. Many studies place strong emphasis on worker knowledge and training as a primary factor in food contamination risks. However, they overlook broader systemic issues such as workplace conditions and structural inequalities that affect these workers. Only a few studies have demonstrated how systemic factors, such as precarious employment, working while ill, and low wages, impact worker health and, in turn, compromise food safety (Yim & Katare, 2023; Clayton et al., 2016). However, the effect of deportations of unauthorized immigrant workers that shape the workforce in these industries has yet to be examined. Therefore, this paper investigates whether deportations influence workforce dynamics and worker performance, consequently affecting food safety in meat and poultry processing facilities.

2. DATA

2.1. Deportations due to immigration related violations

Deportations refer to the formal removal of immigrants living in the US without legal authorization when they are found violating immigration laws. It reflects the effectiveness and adherence to immigration enforcement priorities, serving as a concrete indicator of how immigration policies are practically implemented and their overall impact (Amuedo-Dorantes & Antman, 2021). We utilize deportations as a measure of federal immigration enforcement priorities to explore their impact on food safety at meat and poultry processing establishments. Our focus is solely on the number of deportations where the most serious criminal conviction (MSCC) was an immigration violation, as these likely indicate the lowest tolerance for immigrant workers, as suggested by Ameudo-Dorantes & Antman (2021). Such offenses include illegal entry, illegal re-entry, possession of fraudulent immigration documents, forgery of identification documents, falsifying citizenship, and obstructing justice.

We collected data on the number of deportations related to the most serious criminal convictions from 2004 to 2019, sourced from the Transactional Records Access Clearinghouse (TRAC). The data were collected in May 2024. TRAC is a nonpartisan, nonprofit organization for data-gathering, research, and distribution based at Syracuse University. TRAC includes information on Immigration and Customs Enforcement (ICE) deportations, compiled from individual case records obtained from ICE through Freedom of Information Act (FOIA) requests. This data excludes deportations processed by Customs and Border Protection at the border, unless prolonged detention resulted in the transfer of custody to ICE. It collects information on deportations stemming from various immigration enforcement initiatives and provides details about the city and state of the port from which individuals were deported, as well as the period (month and year) of their deportation. We collected data at the state and month levels, enabling us to exploit the variation in the number of deportations across months, states, and the intensity of deportations.

Deportations are an observable outcome of immigration enforcement, but they do not occur immediately after an arrest. The deportation process involves court proceedings, appeals, and administrative delays, meaning that monthly deportation counts reflect immigration enforcement actions initiated earlier. To account for the potential delay between an arrest and removal, we compute a moving average of monthly deportations from each state, which serves as our primary independent variable of interest. The moving average of deportations is calculated as the average of the current and the previous month's deportations, following the approach of Amuedo-Dorantes (2021). The average monthly deportations at the state level are 526, and there are 2,668 state-month observations in which no deportations occurred.

2.2. Awareness of Immigration Enforcement

News report on workplace raids, arrests, and shifts in immigration policy serves as a warning or deterrent, generating fear, uncertainty, and behavioral changes among the immigrant population, as well as chilling effects on U.S. natives and other documented populations (Hacker et al., 2011; Lopez et al., 2016; Alsan & Yang, 2022). These effects may include increased Google searches for terms related to ICE (Cat, 2025), reduced labor force participation (Ameudo-Dorantes & Antman, 2021), and diminished morale and productivity at work (Oliveira et al., 2022). Therefore, we utilize Google Trends data and create a Google Trends index that captures public concerns and awareness regarding immigration raids from 2004 to 2019. Google Trends is a publicly available database starting from 2004. It provides a search volume index ranging from 0-100, which is the relative popularity of a search term entered in Google's search engine and measured as a share of a random sample of Google queries in a specific time and location.

For the commonly searched terms related to raids: ICE raid, ICE raids, Immigration raid, Immigration raids, we collected a monthly time series of their search interest for each state[1]. From the search data, we are unable to identify who is querying the search words. However, we assume that fear of immigration raids increases the likelihood of searching the related terms, making these search terms a proxy for measuring fear among immigrant populations, even if not everyone who searches fears raids or vice versa. Following Stephens-Davidowitz (2014), we collected 100 samples of state-monthly time series for each keyword and calculated an average Google Trends score across these samples for each state, month, and keyword. Vermont has no observable search interest data and was excluded from the analysis sample. In our analysis sample, the collected GT score for relevant search term *i* in state *s* in month *t* can be represented by Equation 1.

$$\mathrm{G}\,(i,t;s) = \left[100 * \frac{\text{share}\,(i,t;\ s)}{max_{\mathrm{t}}\{share\ (i,t;\ s\ )\}}\ 1(\#(i,t;\ s) > T)\right] \tag{1}$$

where, share *(i, t; s)* = # *(i, t; s)* / # *(t; s)*, # *(i, t; s)* represents the number of searches for term *i* in state *s* in month *t*, whereas # *(t; s)* represents the number of all searches in state *s* in month *t*, and $max_{\mathrm{t}}\{share\ (i,t;\ s)\}$ is the maximum share of searches for term *i* in state *s*, taken over all of the months in the state-level sample. T is a threshold value of searches that must be exceeded for Google to permit access to the data, and 1*(# (i, t; s)* > T) is an indicator function capturing the fact that only observations of G *(i, t; s)* for which the number of searches for relevant term *i* in state *s* in month *t* exceeds the Google-determined threshold T will be positive. Thus, under this expression, for each state s, G *(i,t; s)* is equal to 100 in the month in which the share of searches

[1] The last data were collected in January 2025. Google Trends data are case-insensitive, so searches that include "ICE raids" also include "ice raids.

containing *i* is highest and equal to a positive number smaller than 100 in all other months that have enough searches containing *i*.

Following Burchardi et al. (2019) and Ameudo-Dorantes & Antman (2021), we aggregate the search intensities across all terms to create our Google Trends awareness index at the state-month level. To aid in interpreting results, we normalize the resulting summed index by dividing it by the maximum observed search intensity across all states and months, multiplied by 100. This normalization enables us to directly compare immigration raids awareness across both states and months. The final measure ranges from 0 to 100, with higher values indicating greater immigration raids-related search activity, and corresponding awareness and fear. The average national monthly search intensity was 1.27 from 2004 to 2019.

By analyzing trends in these search terms, we aim to understand how perceived threats of immigration raids may influence the behavior and well-being of immigrant workers employed in meat and poultry processing establishments, and consequently, affect inspection violation rates. This data complements the broader analysis of deportation patterns, food safety, and consumer welfare. A limitation of using Google Trends data in our study is that it does not account for the varying internet access among vulnerable undocumented immigrant populations. Limited internet access may result in underrepresentation in search data, suggesting that actual fear levels could be significantly higher than what is reflected in the trends.

2.3. Meat and Poultry Inspection Reports

We obtained inspection task reports from 2004 to 2019 for federally inspected meat and poultry processing establishments by submitting a Freedom of Information Act (FOIA) request to the USDA Food Safety and Inspection Service (FSIS). The Meat and Poultry Inspection (MPI) task reports contain detailed records of daily inspection activities, indicating compliance levels with

FSIS food safety standards and regulations. Compliance with food safety standards and regulations in meat and poultry processing establishments is often evaluated based on the number of non-compliances or inspection violations cited during inspections. The MPI reports include detailed information on the establishment's name, date, and number of inspections, inspection task names, inspection types such as HACCP, sanitation, and the number of documented non-compliances. Additionally, the MPI directory provides demographic information about each establishment, such as its name, type, size, and location.

We use inspection task reports from approximately 6,000 federally inspected meat and poultry processing establishments observed in any given year between 2004 to 2019 across 47 contiguous US states and the District of Columbia. FSIS uses a data system to record the results of the procedures performed during an inspection and to detect and respond to foodborne hazards. For the timeframe of our study, FSIS used both the Performance Based Inspection System (PBIS) and the Public Health Information System (PHIS). The MPI report was under the regulation of PBIS (Performance Based Inspection System) before 2012 and switched to PHIS (Public Health Information System[2]. Meat and poultry processing establishments undergo two types of inspections: routine and directed. Routine inspection tasks occur regularly whenever the establishment is in operation, ensuring ongoing compliance with food safety standards. In contrast, directed inspection tasks are conducted on an as-needed basis when an inspector identifies a concern or violation during a routine inspection. For our main analysis, we focus on both routine and directed inspection tasks and only consider the inspection tasks that are conducted throughout the study years for consistency.

[2] Details are available at https://www.usda.gov/sites/default/files/documents/fsis-pbis-pia.pdf. We lack identifiers for the type of inspection either routine or directed and the shift of operation in the PBIS system.

An inspection task refers to a verification or data recording activity conducted by Inspection Program Personnel (IPP) to ensure food safety compliance at meat and poultry processing establishments. These inspections include but are not limited to 1) Hazard Analysis Critical Control Point (HACCP), 2) Sanitation (USDA-FSIS, 2023). For this analysis, we focus on HACCP and sanitation inspection type as they are directly tied to food safety and consumer welfare and can be influenced by the workers (USDA-FSIS, 2023). HACCP inspection type includes tasks such as hazard analysis verification and ensuring establishments have properly documented and implemented HACCP plans. Sanitation inspection types include tasks such as reviewing records and observing Sanitation Standard Operating Procedures (SSOPs) during both operational and pre-operational periods, verifying Sanitation Performance Standards (SPS), implementing generic E. coli programs, and conducting sanitary dressing procedures. While SSOPs typically focus on workers' hygiene and actions, SPS applies to the overall establishment conditions. Therefore, we used the HACCP inspection type, two tasks under the sanitation inspection type, namely pre-operational SSOP and operational SSOP, and the sanitation inspection type, altogether excluding the SPS inspection task.

The MPI task reports provide inspection data at a daily level. However, FSIS inspections occur mandatorily for each establishment only on their operating days, which can be daily for most routine tasks, while others follow monthly, quarterly, or annual schedules. So, we followed previous literature (Yim and Katare, 2023) and aggregated the daily inspection data into monthly records and calculated the four main outcomes: inspection violation rate of HACCP, pre-operational SSOP, operational SSOP, and sanitation inspections at the establishment monthly level using Equation 2. Inspection violation rate reflects the food safety level of the establishments (USDA-FSIS, 2023).

$$VR_{ipt} = \frac{(Total\ number\ of\ non-compliance\ records)_{ipt}}{(Total\ number\ of\ inspections)_{ipt}} \quad (2)$$

Where VR_{ipt} is the violation rate for the inspection i in the establishment p during the month t, $(Total\ number\ of\ inspections)_{ipt}$ is the total number of inspections for the inspection i conducted at the establishment p during the month t, and $(Total\ number\ of\ non-compliance\ records)_{ipt}$ is the total number of inspections that received non-compliance for the inspection i at establishment p during the month t. The average violation rates of HACCP, pre-operational SSOP, operational SSOP, and sanitation inspections are 1%, 2.3%, 1%, and 1.6%, respectively.

2.4. Worker Wages, Employment, Turnover, Hires, and Separations

In our main analysis, we implicitly assume that deportations due to immigration related violations disrupt the workforce of the meat and poultry processing industry, causing labor shortages. Since a continuous labor supply is critical, the employers will need to hire aggressively to meet their operational needs. However, the share of workers willing to work in the industry is already small given its low wages, high rates of injury, strenuous nature of work, and historical relocation to rural areas (Orrenius & Zavodny, 2009; Krumel, 2017; Whittaker, 2006). Deportations exacerbate the situation further by decreasing the supply of available labor, leading to scarcity. As employers need to compete for a smaller workforce, they might have to raise wages to attract new workers or retain those still available (Call & Stuesse, 2024). To support this, we analyze employment, wages, hires, turnovers and separations data for workers in animal slaughtering and processing industries or occupations related to meat industry for example, butchers and cutters from three primary sources: 1) the Current Population Survey Outgoing Rotation Group (CPS-ORG), 2) the Quarterly

Workforce Indicators (QWI) and 3) Occupational Employment and Wage Statistics (OEWS). Our data covered 47 contiguous US states and the District of Columbia between 2004 and 2019.

The CPS-ORG data is a monthly household survey conducted by the US Census Bureau on behalf of the Bureau of Labor Statistics (BLS). We use the hourly and weekly wages for households that are primarily employed in animal slaughtering and processing industries (Census Industry code 1180) to construct monthly state-level data. We concentrate only on the occupation that is more related to the meat and poultry processing workers, which is Butchers and other meat, poultry, and fish processing workers (occupation code: 51-3020). The QWI data provides quarterly industry-level labor market statistics by county. This data is sourced from administrative records compiled by the US Census Bureau. We construct quarterly state-level data with four labor flow outcomes (employment, turnover, hires, and separations) of workers in the animal slaughtering and processing industry (NAICS 3116). The OEWS data is a yearly industry-level dataset by state. We use the mean hourly and mean annual wages and annual total employment of workers who are 1) Butchers and meat cutters (occupation code: 51-3021), 2) Meat, poultry, and fish cutters and trimmers (occupation code: 51-3022), and 3) Slaughterers and meat packers (occupation code: 51-3023) to construct yearly state-level data. These occupations represent the core production and processing roles within meat and poultry processing establishments (BLS, 2021). We match CPS-ORG data to the state-by-month deportations, QWI data to the state-by-quarter deportations, and OEWS data to state-by-year deportations.

2.5. Empirical Framework

We combine TRAC data on ICE deportations with Google Trends awareness index for immigration raids at the month-year level for each state. We then combine meat and poultry inspection violation rates of each meat and poultry processing establishment from FSIS with

combined TRAC and Google Trends data at the month-year level based on the state each establishment is located in. The final dataset includes 3,736,743 monthly inspection records from approximately 6000 establishments observed in any given year in 47 contiguous US states and the District of Columbia between 2004-2019. This state-month panel data provides plausibly exogenous geographic and temporal variation in the intensity of deportations and Google search intensity for immigration raids, allowing for the estimation of their effects on the food safety response in meat and poultry processing establishments.

Two-way Fixed Effects Model: We apply the two-way fixed effects as shown in our preferred specification, Equation 3. In this model, the meat and poultry inspection violation rate VR_{ipst} for inspection *i* in the establishment p of state *s* during the month t is regressed on the moving average of deportations ($Deportations_{st}$) and Google awareness index ($Awareness_{st}$) of immigration raids in state *s* during the month *t*. We also include establishment fixed effects α_p and month-year fixed effects α_t to control for unobserved establishment characteristics and common time-invariant factors that affect an establishment's meat and poultry inspection violation rate. We also add control variables $\boldsymbol{X_{p,st}}$ matched to the state each establishment is located in, which includes state-level time-varying demographic and economic factors such as log annual unemployment rate, log annual population estimates, and the establishment-level time-varying inspection characteristics, including the log of total number of corresponding inspection tasks conducted at the establishment p in the given month *t*. Standard errors are corrected for heteroscedasticity and clustered at the state-month level. Since deportations are recorded at the state-month level and inspection violations at the establishment level, multiple establishments within a state experience similar workforce disruptions and regulatory enforcement patterns. State-month clustering accounts for within-state correlations and serial dependence over time, ensuring standard errors accurately

reflect shared workforce shocks, enforcement policies, and seasonal trends. Prior research highlights the importance of clustering in panel data when policy interventions exhibit group dependencies (Cameron & Miller, 2015). Equation 3 is the level-level specification where coefficients $\beta 1$ and β_2 can be interpreted as changes in meat and poultry inspection violation rates (%) caused by a unit increase in the number of individuals deported (in thousands) and a unit increase in immigration raids awareness, respectively.

$$VR_{ipst} = \beta_0 + \beta_1 Deportations_{st} + \beta_2 Awareness_{st} + \alpha_p + \alpha_t + \boldsymbol{X_{p,st}}\gamma + \varepsilon_{pct} \quad (3)$$

Distributed Lag Model: In addition to estimating the contemporaneous effect of deportations in Equation 3, we also employ a distributed lag model (DLM) to examine the dynamic relationship between deportations and meat and poultry inspection violation rate, as shown in Equation 4. We use a DLM approach because it provides an important identification strategy. Finding no significant leads (pre-trends) suggests a causal link. Furthermore, it allows us to use a continuous deportation variable and, therefore, is more comparable to our baseline two-way fixed effects model. This flexible specification replaces the single continuous deportations variable with a series of lags and leads of deportations denoted as $Deportations_{s,t-m}$. The coefficients β_m measure the changes in monthly inspection violation rates for the inspection i in an establishment p in state s with respect to deportations m months ago or m months in the future. Standard errors are corrected for heteroscedasticity and clustered at the state-month level.

$$VR_{ipst} = \beta_0 + \sum_{m=-k}^{k} \delta_m Deportations_{s,t-m} + \alpha_p + \alpha_t + \boldsymbol{X_{p,st}}\gamma + \varepsilon_{pct} \quad (4)$$

$d_m s$ only calculates the contemporaneous effects of deportations at lags and leads, however, we also need to calculate the total effect before and after deportations. For this, we select a reference period as k = -1 and set $\beta_{-1} = 0$ following East et al. (2023). We then sum up the distributed lag coefficients relative to this period. For periods before the reference period (k<-1), we cumulate the coefficients negatively so that $\beta_{-2} = -\delta_{-1}$, $\beta_{-3} = -\delta_{-1} - \delta_{-2}$. For periods k>-1, we cumulate positively so that $\beta_0 = \delta_0$, $\beta_1 = \delta_0 + \delta_1$ and so on. The leads (k < 0) test for pre-deportation changes in inspection violation rates and provides a very useful falsification test that is common in the literature, while the lags (k > 0) test for post-deportation changes in inspection violation rates, showing if and how quickly the deportations impact materializes and evolves. We chose an event window of four months before (k=-4) and four months after deportations (k = 4) to show the short-run effect of deportations on meat and poultry inspection violation rates. This provides us with an event window of 9 months, which is long enough to test pre-trends as deportations are expected to have changes in workers' behavior and composition in the industry in the short term (Kammer, 2009). If we increase the lags and leads, we increase the chances that underlying changes in the establishments sample will affect our estimates.

Labor Market Specification: We also analyzed wages and labor flows data from multiple sources to assess the impact of deportations in the meat and poultry processing industry. We estimate the following two-way fixed effects model to explore the relationship between deportations and meat industry worker's labor market outcomes which includes (i) hourly and weekly wages (CPS-ORG), (ii) flow employment, turnovers, stable hires and separations (QWI data) and (iii) total estimated employment, mean hourly and annual wages (OEWS data). This approach allows us to capture variations in workers' wages and workers' flow following deportations across different geographic and temporal levels.

$$\ln(Y_{st}) = \alpha + \beta \ln(Deportations_{st}) + \alpha_s + \alpha_t + \boldsymbol{X_{it}}\gamma + \varepsilon_{it} \quad (5)$$

The natural log of labor market outcomes (Y_{st}) for a state *s* during time *t* is regressed on the natural log of deportations with state fixed effects (α_s) and time fixed effects (α_t; *m*onth (CPS-ORG), quarter (QWI), and year (OEWS)). To avoid undefined values by log transformation of observations with zero deportations, we add a constant 0.001 to each observation before log transforming them. The constant directly corresponds to the variable's smallest meaningful unit of measurement (representing 1 person), making the transformation intuitive and interpretable in real real-world context. Adding a constant before log transformation is a widely used concept in the research (MaCurdy & Pencavel, 1986). The vector of controls $\boldsymbol{X_{it}}$ includes the state-level time-varying demographic and economic factors, including the log unemployment rate and log population. For analysis using CPS-ORG data, we additionally control the race, gender, and marital status of the workers. For the QWI data, we additionally control for gender and age indicators, while for the OEWS data, we additionally control for occupation indicators. Standard errors are corrected for heteroscedasticity and clustered at the state-month (CPS-ORG), state-quarter (QWI), and state-year (OEWS) levels. The log-log specification in Equation 5 allows β to be interpreted as the elasticity of labor market outcomes with respect to deportations.

3. RESULTS AND DISCUSSION

3.1. Consumer's Food Safety

Table 1 shows the contemporaneous effect of deportations on the meat and poultry inspection (MPI) violation rate from the two-way fixed effects model described in Equation 3. Table 1 displays results from eight separate regressions for four main outcomes. The outcome variables are: inspection violation rate for HACCP (Columns 1 and 2), inspection violation rate for pre-

operational SSOP (Columns 3 and 4), inspection violation rate for operational SSOP (Columns 5 and 6), and inspection violation rate for sanitation (Columns 7 and 8).

Our main results are depicted in Columns 2, 4, 6, and 8 of Table 1. Results show that a higher number of deportations is associated with a significant increase in the inspection violation rate for all kinds of inspections. The estimated effects imply that an additional 1000 deportations in a month across a state can significantly increase HACCP inspection violations rate by 0.033% ($p<0.01$) and pre-operational SSOP inspection violations rate by 0.033% ($p<0.01$), operational SSOP inspection violations rate by 0.009% ($p<0.10$) and sanitation inspection violations rate by 0.018% ($p<0.01$). Specifically, for every additional 1,000 deportations in a month across a state, approximately 3 out of 10,000 inspections across all establishments in that state might not comply with HACCP standards. Similarly, awareness of immigration raids has no significant effect on the inspection violation rate for all kinds of inspections. The results are robust to the exclusion of establishment-level inspection characteristics and state-level demographic and economic factors as depicted in Columns 1,3,5, and 7.

Several case studies illustrate how a single inspection violation can trigger massive product recalls, endanger public health, and lead to severe financial and legal repercussions for meat and poultry processors. At Topps Meat Company, LLC, New Jersey, in 2007, non-compliance with HACCP protocols (inadequate process controls in the non-ground beef production processes) resulted in the recall of 21.7 million pounds of ground beef, the second-largest beef recall in US history. This led to 40 confirmed cases of E. coli infection across eight states and ultimately resulted in the company's shutdown after 67 years of operation (CDC, 2024). Another case of inspection violation in the processing of ready-to-eat chicken salad at Triple T Specialty Meats, Iowa, in 2018, caused a Salmonella outbreak resulting in 265 illnesses, 94 hospitalizations, and one death spread across

8 states. Consequently, it also resulted in the loss of a major retail partner, “Fareway Stores” (Marler, 2018). Therefore, the observed increases in inspection violation rates at meat and poultry processing establishments following the deportations have huge public health significance for consumers and financial significance for companies.

Table 1: Effect of deportations on the meat and poultry inspection violations rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	HACCP		Pre-operational SSOP		Operational SSOP		Sanitation	
Deportations	0.034***	0.033***	0.047***	0.033***	0.011**	0.009*	0.026***	0.018***
	(0.008)	(0.007)	(0.013)	(0.010)	(0.005)	(0.004)	(0.009)	(0.007)
Immigration raids awareness	0.002*	0.002	0.003	0.002	0.001	0.0005	0.002	0.001
	(0.001)	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
R-sqr	0.091	0.096	0.302	0.303	0.318	0.319	0.191	0.193
Outcome mean (level)	0.997	0.997	2.245	2.245	1.027	1.027	1.595	1.595
Number of observations	888,871	888,871	892,451	892,451	896,292	896,292	1,902,685	1,902,685
Cluster Level	State-month	State-month	State-month	State-month	State-month	State-month	State-month	State-month
No of establishments	8,333	8,333	8,505	8,505	8,550	8,550	8,608	8,608
No of Clusters	8,559	8,559	8,560	8,560	8,562	8,562	8,562	8,562
Establishment FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes

*Notes: Standard errors are corrected for heteroscedasticity and clustered at the state month level. * p <0.1, **p<0.05, ***p < 0.01. All the estimations control for month year fixed effects and establishment fixed effects. Columns 2, 4, 6 and 8 additionally include establishment level time varying inspection characteristics such as log total number of inspections conducted in the corresponding establishment in each state and month and state level time varying demographic and economic factors such as log annual unemployment rate and log annual population estimates.*

3.2. Dynamic Effects of Deportations

Our underlying identification assumption is that deportations are an exogenous shock that can affect the meat and poultry inspection violations rate at meat and poultry processing establishments. For this assumption to be valid, there should be no systematic change in the meat and poultry inspection violations rate in the absence of a deportation (i.e., before a deportation). To validate this assumption, we estimate a distributed lag model described in Equation 4 and calculate the cumulative effects at each month, four months before, and four months after deportations.

Figure 1 presents the estimated cumulative effects of the change in the meat and poultry inspection violations rate before and after deportation. We focus on the HACCP inspection violation rate (Panel 1: Column 1), pre-operational SSOP inspection violation rate (Panel 1: Column 2), operational SSOP (Panel 2: Column 1), and sanitation inspection violation rate (Panel 2: Column 2). We see no evidence of significant changes in HACCP, pre-operational SSOP, operational SSOP, and sanitation inspection violation rates in the months leading up to the deportations, implying that deportations do not affect the historical inspection violation rate. The results in Figure 1 show no significant pre-trends, thus supporting our identification assumption.

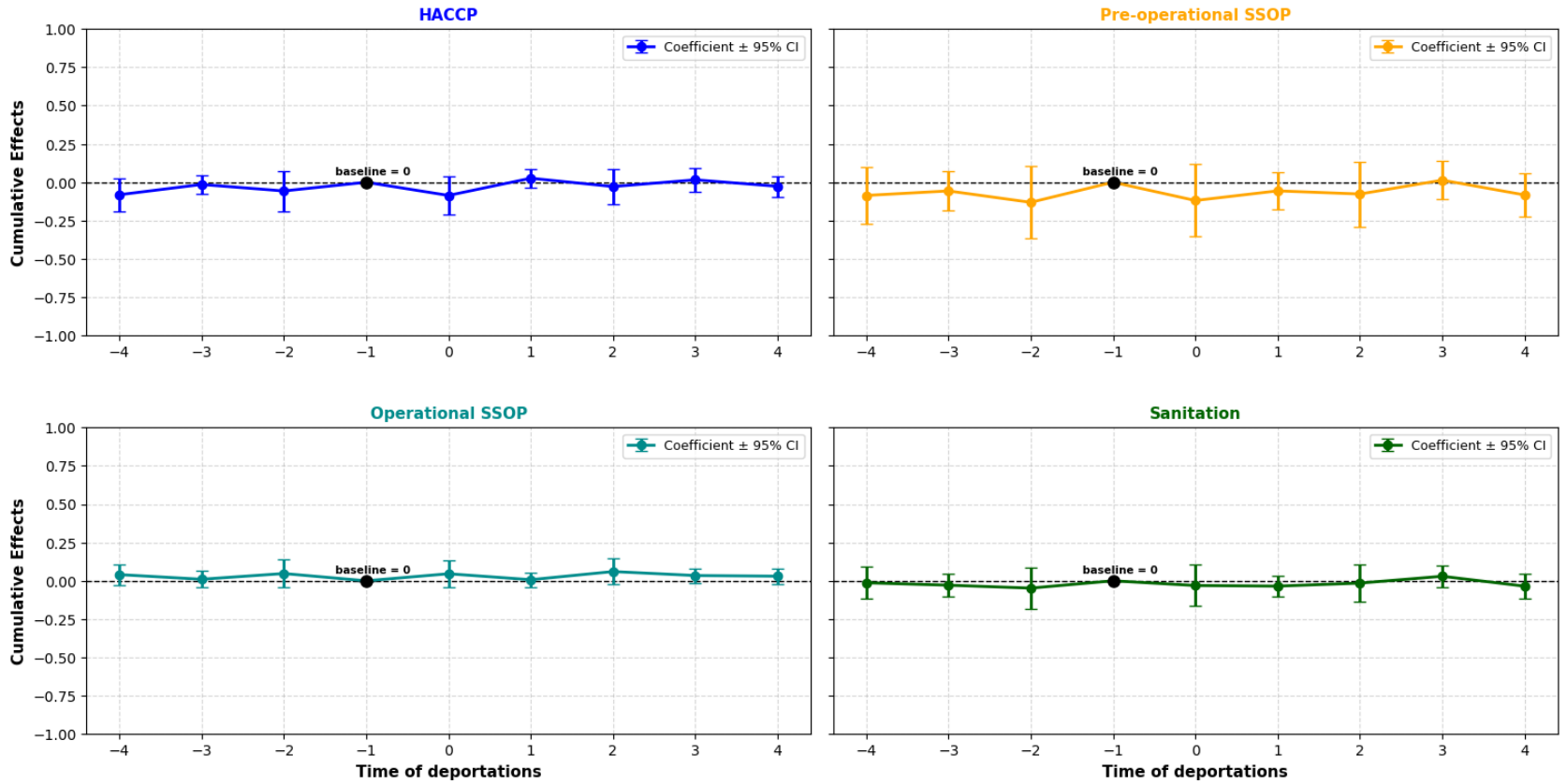

Figure 1: Cumulative effect of deportations on the meat and poultry inspection violations rate

Notes: This figure plots the sum of estimated coefficients δ_m ("cumulative effect") for each period, along with the 95% confidence intervals, from regressions using a distributed lag model in Equation 4. Standard errors are corrected for heteroscedasticity and clustered at the state-month level. All the estimations control for time-fixed effects, establishment fixed effects and establishment-level time-varying inspection characteristics such as log total number of inspections conducted in the corresponding establishment in each state and month and state-level time-varying demographic and economic factors such as log annual unemployment rate and log annual population estimates. We fix the baseline period to k=-1 and normalize the deportations effect to zero at k=-1. The pre-event cumulative effect at k months before deportations is calculated as $-\sum_{m=-1}^{m=-k}\delta_m$ and the post-event cumulative effect at k months after deportations is calculated as $\sum_{m=0}^{m=k}\delta_m$.

3.3. Mechanisms

3.3.1. Worker Wages and Earnings

Table 2 shows how the wages of meat industry workers change when deportations reduce the supply of low-wage labor, such as undocumented immigrants, using data from CPS-ORG and OEWS in Equation 5. Results for the hourly wages are presented in Columns 1 and 2, weekly wages in Columns 3 and 4, mean hourly wage in Columns 5 and 6, and mean annual wage in Columns 7 and 8. The hourly wage and weekly wage elasticities with respect to the deportations are 0.03 ($p<0.001$) and 0.02 ($p<0.10$), respectively, from the monthly CPS-ORG data. The mean hourly wage and mean annual wage are not significantly affected by the deportations, as found from the yearly OEWS data. Results are robust to the exclusion of controls.

While employers respond to immediate labor shortages with increased wages in monthly CPS-ORG data, we see no lasting effect in wage increases from yearly OEWS data, suggesting employers adjust over time. These findings are consistent with Kammer (2009), which shows that following ICE raids, employers increased wages by an average of 8% alongside other benefits to attract and retain workers. Additionally, the company hired more US citizens and Somali refugees, shifting the workforce composition, which is also consistent with the findings of Orrenius & Zavodny (2022). Similarly, in the case of farm labor, Richards (2018) simulated an increase in agricultural wages by over 22% when 50% of all unauthorized farm workers were removed from the California farm labor market.

Table 2: Deportations and wage elasticities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log (hourly wages)	Log (hourly wages)	Log (weekly wages)	Log (weekly wages)	Log (mean hourly wage)	Log (mean hourly wage)	Log (mean annual wage)	Log (mean annual wage)
Deportations	0.030***	0.026***	0.023***	0.019*	0.0009	0.0008	0.0009	0.0008
	(0.008)	(0.010)	(0.009)	(0.011)	(0.002)	(0.002)	(0.002)	(0.002)
R-sqr	0.187	0.224	0.138	0.169	0.742	0.742	0.792	0.792
Outcome mean (level)	14.02	14.02	574.89	574.89	14.70	14.70	26863.05	26863.05
No. of Observations	1,436	1,436	1,439	1,439	2,140	2,140	2,140	2,140
Cluster Level	State-month	State-month	State-month	State-month	State-year	State-year	State-year	State-year
No. of Clusters	757	757	759	759	768	768	768	768
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Monthly	Monthly	Monthly	Monthly	Yearly	Yearly	Yearly	Yearly
Controls	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Data	CPS-ORG	CPS-ORG	CPS-ORG	CPS-ORG	OEWS	OEWS	OEWS	OEWS

*Notes: Standard errors are corrected for heteroskedasticity and clustered at the state month (state year) level. * p<0.1, **p<0.05, *** p<0.01. All the estimations control for time fixed effects, and state fixed effects while it also includes occupation indicators in OEWS data. Columns 2, 4, 6 and 8 additionally control for state-level time varying economic factors including log annual unemployment rate and log annual population estimates. CPS-ORG data also controls for race, gender and marital status of worker's indicators.*

3.3.2 Worker Employment, Turnover, Hires, and Separations

Table 3 shows how the meat industry workers flow across the industry in response to deportations using data from the OEWS and QWI in Equation 5. From OEWS data, results for employment are presented in Columns 1 and 2. Similarly, for QWI data, results for the employment are presented in Columns 3 and 4, turnover in Columns 5 and 6, hires in Columns 7 and 8, and separations in Columns 9 and 10. From QWI data, the employment and turnover elasticities with respect to the deportations are 0.016 ($p<0.001$) and -0.008 ($p<0.10$), respectively. Similarly, the hires and separations elasticities with respect to deportations are 0.019 ($p<0.001$) and 0.020 ($p<0.001$), respectively. We don't see any significant impact on employment in the yearly OEWS data. Results are robust to the exclusion of controls.

We see a significant increase in separations because unauthorized workers or those affected by enforcement leave their positions. Similarly, increased hiring aligns with employers actively replacing workers who leave due to deportations with new hires to maintain their operations. This may include hiring of native-born workers or other legal immigrant workers, potentially boosting employment among these groups (Kammer, 2009; Orrenius & Zavodny, 2022). Increased hires, separations, and employment following deportations are also consistent with the findings of Orrenius and Zavodny (2024). In addition, we find reduced turnover, which aligns with employers stabilizing their workforce with authorized workers who are more likely to stay long-term.

Table 3: Deportations and labor flow elasticities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log (employment)	Log (employment)	Log (employment)	Log (employment)	Log (turnover)	Log (turnover)	Log (hire)	Log (hire)	Log (Separation)	Log (Separation)
Deportations	-0.003	-0.004	0.013***	0.016***	-0.009*	-0.008*	0.015**	0.019***	0.017***	0.020***
	(0.010)	(0.009)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)	(0.005)	(0.006)
R-sqr	0.721	0.722	0.135	0.320	0.063	0.062	0.132	0.211	0.129	0.194
Outcome Mean (level)	2853.384	2853.384	231.82	231.82	0.127	0.127	29.20	29.20	35.41	35.41
Number of observations	2, 030	2, 030	159,399	159,399	62,787	62,787	71,918	71,918	86,466	86,466
Cluster Level	State-year	State-year	State-quarter	State-quarter	State-quarter	State-quarter	State-quarter	State-quarter	State-quarter	State-quarter
No. of Clusters	766	766	2,968	2,968	2,653	2,653	2,677	2,677	2,785	2,785
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yearly	Yearly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Data	OEWS	OEWS	QWI	QWI	QWI	QWI	QWI	QWI	QWI	QWI

*Notes: Standard errors are corrected for heteroskedasticity and clustered at the state year (quarter) level. * p<0.1, **p<0.05, *** p<0.01. All the estimations control for time fixed effects and state fixed effects. Column 1 additionally control for occupation indicators. Columns 2, 4, 6, 8 and 10 additionally control for state-level time varying economic factors including log annual unemployment rate and log annual population estimates. QWI data also controls for gender and age indicators.*

Results in Tables 2 and 3 support our assumption that deportations contribute to labor shortages as evidenced by a rise in worker separations (increased number of workers leaving their jobs). Businesses adjust their labor challenges by increasing wages, hiring, and employment. However, increased wages and labor reallocation do not entirely offset the negative effect on aggregate industry food safety outcomes, as evidenced by increased meat and poultry inspection violation rates following the deportations. Retaining experienced workers is therefore critical in meat and poultry processing establishments, where food safety compliance depends heavily on worker adherence to safety protocols, proper handling procedures, and regulatory guidelines.

4. CONCLUSION

We provide the first empirical evidence on how immigration enforcement, captured through deportations and heightened awareness of immigration raids, affects food safety in meat and poultry processing establishments. Our findings suggest that deportations have tangible negative consequences for food safety and consumer welfare, evident from increased inspection violations at meat and poultry processing establishments. However, awareness of immigration raids had no impact. These results highlight the broader operational and public health consequences of strict immigration enforcement in industries dependent on immigrant labor. As immigration enforcement priorities continue to evolve, especially amid the current administration's plan to deport 1 million undocumented immigrants per year (Sacchetti & Bogage, 2025), these findings underscore the importance of considering the unintended spillover effects of immigration policy on critical sectors like food processing. One limitation of our study is the inability to examine individual-level responses to deportations due to data constraints. Future research should explore how individual worker characteristics shape responses to deportations to further understand labor dynamics and their impact on food safety.

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