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An estimate of the US government's undercount of nonfatal occupational injuries and illnesses in agriculture

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Abstract

Background—Debate surrounds the accuracy of US government's estimates of job-related injuries and illnesses in agriculture. Whereas studies have attempted to estimate the undercount for all industries combined, none have specifically addressed agriculture.

Method—Data were drawn from the US government's premier sources for workplace injuries and illnesses and employment: the Bureau of Labor Statistics databanks for the Survey of Occupational Injuries and Illnesses (SOII), the Quarterly Census of Employment and Wages (QCEW), and the Current Population Survey (CPS). Estimates were constructed utilizing transparent assumptions; e.g. that the rate (cases-per-employee) of injuries and illnesses on small farms was the same as on large farms (an assumption we altered in sensitivity analysis).

Results—We estimated 74,932 injuries and illnesses for crop farms and 68,504 for animal farms, totaling 143,436 cases in 2011. We estimated that SOII missed 73.7% of crop farm cases and 81.9% of animal farm cases for an average of 77.6% for all of agriculture. Sensitivity analyses suggested that the percent missed ranged from 61.5% to 88.3% for all agriculture.

Conclusion—We estimate that there is considerable undercounting of nonfatal injuries and illnesses in agriculture and believe more than occurs in other industries. Reasons include: SOII's explicit exclusion of employees on small farms and of farmers and family members and QCEW's undercounts of employment. Undercounting limits our ability to identify and address occupational health problems in agriculture, affecting both workers and society.

Keywords

job-related injuries; crops; livestock

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The federal government's undercount of nonfatal occupational injuries and illnesses for all industries combined has received considerable research and popular press attention[1–3]. A US General Accounting Office report addressed undercounting and suggested remedies for all industries combined[4]. This study extends previous research by focusing on agriculture, an industry that merits special attention for several reasons. First, although estimates vary, agriculture employs roughly 2 to 4 million people, and includes the highest share of self-employed persons in any industry[5,6]. Second, agriculture is among the most hazardous industries, especially for the self-employed[7–9]. Third, agriculture employs many undocumented workers; for example, the most recent analysis from the National Agricultural Workers Survey (NAWS) estimated 53% of all hired crop workers were undocumented[10]. Contentious debate surrounds whether undocumented workers should be granted citizenship and the impact this may have on workers' subsequent use of Medicaid and workers' compensation[11,12]. Fourth, many farm workers are migrants; the NAWS estimated 42% of crop workers annually traveled 75+ miles to obtain jobs[10]. Fifth, and most importantly, agriculture poses the greatest challenge of any industry for generating estimates of undercounting because of the seasonal nature of employment, and predominance of small, family-run operations[13].

We measured the injury and illness undercount as the difference between estimates from the Bureau of Labor Statistics (BLS)'s Survey of Occupational Injuries and Illnesses (SOII) and our own estimates. Unlike the SOII, we accounted for the self-employed and workers on small farms as well as willful and negligent underreporting by both employees and employers. We believe our estimates are conservative, in part because we use the same criteria as the BLS to qualify a case as an occupational injury or illness. We do not include, for example, estimates of job-related cancers, COPD, and circulatory disease that far exceed those recognized by the SOII[14,15].

The undercount has institutional and behavioral causes. Institutional causes pertain to deliberate reasons for excluding persons. Two of these institutional causes are the exclusions of self-employed farmers on all farms and workers on farms with <11 employees from the SOII. A third institutional cause is the government's undercount of employment of farm workers in virtually all government data sets. This employment undercount is widely recognized owing to the fluid and part-time nature of farm work[7]. BLS readily acknowledges the employment undercount and estimates its magnitude in supplements to the Quarterly Census of Employment and Wages (QCEW)[16].

There are two behavioral causes: negligence (e.g., employer inadvertently fails to record qualifying injuries in the OSHA log) and willful underreporting (e.g., employer purposefully fails to record qualifying injuries or employees do not notify employers for lack of knowledge regarding reportable injuries or fear of reprisal)[1,2].

Despite the undercount, the SOII is widely cited by researchers and journalists, in part, because it has been providing the only annual national estimates of nonfatal workplace injuries and illnesses for 40 years. There are three additional data sets with relevant information, but none as comprehensive as the SOII. The National Health Interview Survey (NHIS) provides information on injuries, but not illnesses, nor estimates within industries.

The Census of Fatal Occupational Injuries (CFOI) provides information within agriculture, but only for injury fatalities. The National Agricultural Workers Survey (NAWS) contains data on injuries but only for crop, not animal farms.

Methods

We proceed step-by-step through institutional and behavioral causes. We begin with estimates of the numbers of injuries and illnesses and employment from SOII for farms with 11+ employees. SOII figures are then adjusted upwards based on estimates of employment from QCEW that do not restrict to farms with more than 11 employees. We then add estimates for farm owners and family members based on estimates from the Current Population Survey (CPS). Finally, we adjust estimates to reflect underreporting due to willfulness and negligence.

Employees; Survey of Occupational Injuries and Illnesses (SOII)

The 1970 Occupational Safety and Health Act requires very high percentages of firms to record qualifying work-related injuries and illnesses, i.e., those associated with death, loss of consciousness, lost or restricted work days, or medical treatment beyond first aid[17,18]. Employers use OSHA form 300 to record each incident, including the employees name, job title, date, brief description of the incident, days absent, and other pertinent data. Employers sum the numbers within categories each year. The BLS, Office of Safety, Health, and Working Conditions, surveys roughly 250,000 firms and state and local government agencies, collecting annual OSHA form 300 summaries and compiling them into SOII[17,18]. Based on these data, the BLS Safety Office publishes annual estimates for numbers of non-fatal injuries and illnesses, employment, and incidence rates (cases per full-time employee) within detailed industries including crop and animal farms. Our data on injuries and illnesses are drawn directly from SOII. Our employment data are drawn from QCEW. Incidence rates are for full-time equivalent (FTE) workers. The Safety Office estimates FTE workers using numbers of injuries and illnesses from SOII, employment from QCEW (after eliminating small farms), annual work hours from SOII, and a formula that defines full-time employment as 2,000 work hours per year[19].

Employees; QCEW

QCEW employment data “are derived from the quarterly tax reports submitted to State workforce agencies by employers, subject to State unemployment insurance (UI) laws” as well as federal agencies[20,21]. QCEW does not explicitly exclude farms with <11 employees. Nevertheless, some state laws do not require farms with <10 employees to provide unemployment insurance (UI), and these small farms may not be included in QCEW counts[21,22]. The state with the largest farm worker employment, California, requires UI, even for small farms[22]. QCEW nevertheless recognizes that limitations to its ability to capture all employment within agriculture. QCEW estimates it misses 0.2 million employees in all agricultural industries combined and captures 1.2 million, suggesting it misses 14.3% of farm workers[20].

Employees; Combine SOII with QCEW

In 2011, for crop farms in SOII, the estimate for number of injuries and illnesses ("cases") was 19,700 [19]; the employment estimate was 413,800; the case rate was 5.5 cases per 100 FTE. (Note that the case rate is expressed in terms of FTE and therefore not a simple ratio of 19,700/413,800. The denominator, 413,800, is an annual average and includes some workers with <2,000 hours. FTE estimates combine workers and hours into one metric. One FTE could be two workers who each work 1000 hours or one worker who works 2000 hours.) For animal farms, the corresponding numbers were 12,400 injury or illness cases, 163,600 employed, and 6.7 cases per 100 FTE. The 2011 QCEW numbers for employment (again, not excluding farms with <10 employees) were 531,245 for crop and 230,610 for animal farms.

Our first methodological adjustment was to increase the SOII injury and illness cases estimates in proportion to the difference in the SOII and QCEW employment estimates. For crops, the SOII estimate of 413,800 employed persons must be multiplied by 1.2838 (=531,245/413,800) to bring it up to the QCEW estimate of 531,245 employed persons. If we similarly inflate the number of SOII-reported injury and illness cases, the result is 25,291 cases. The same procedure was applied to animal farms and yielded 17,479 cases. The key assumption (altered in the sensitivity analysis) was that the rate of injury and illness was the same on large and small farms.

The second methodological adjustment pertains to the QCEW underestimate of employment in agriculture. The QCEW is likely to underestimate the number of employees in all industries, but especially in agriculture. In all industries, employers have an incentive to underreport numbers of employees because greater numbers will result in higher total (but not per-worker) payments for both unemployment and workers' compensation insurance[23–25]. This incentive is especially strong in agriculture because significant numbers of workers are undocumented --- roughly 53% in crop farms[10]. It is likely that undocumented workers are much less likely than documented workers to apply for unemployment compensation. In addition, our estimate of the undercount is likely affected by varying UI statutes across states. Legal requirements on employers are not as strict for farms compared to other industries. In most states, UI only applies to farms with 10+ employees[10]. BLS recognizes that there are limitations for the QCEW in measuring agricultural employment: "the QCEW program does provide *partial* (our emphasis) information on agricultural industries... "[26].

We therefore sought to adjust upward the QCEW estimates to reflect employment undercounting. We could not find QCEW undercounting estimates in agriculture in scientific journals. We used alternative QCEW data that estimated 0.2 million out of a total of 1.4 million were omitted from published QCEW tables. These data suggested that the QCEW estimates on which we rely missed 14.29% (=0.2/1.4). This indicates that the observed figure (1.2 million) should be multiplied by 1.1667 (i.e., 1.4 million/1.2 million) to yield the adjusted figure of 1.4 million employees.

Farm owners and family members

This adjustment used data from the BLS's Current Population Survey (CPS) provided by Steven Hipple[27]. We calculated an adjustment factor for expected number of cases based on the fraction of the CPS participants. This fraction is (numbers of wage and salary participants, farm owners and family members) divided by (salary and wage workers). For CPS crop workers, of the total 966,000 participants, 634,000 are salary and wage workers; thus our adjustment factor is 966,000/634,000 = 1.5237. Our crop estimate from above (29,507 cases) that accounted for employees on farms with <11 employees as well as the QCEW underestimate of all agricultural workers was multiplied by 1.5237 and yielded 44,959 cases. This 44,959 estimate relied on the assumption that the case rate for farm owners and family members was the same as for wage and salary workers. A corresponding adjustment factor for animal production cases was also applied.

Willful and negligent underreporting

Employers and employees may deliberately or carelessly not report an injury or illness[1]. We refer to this as a behavioral rather than an institutional cause. Incentives for underreporting for employers may include a desire to reduce workers' compensation insurance premiums, whereas employees may fear that reporting an injury may jeopardize their employment or may not be aware that they should report an injury. The extent of willful and negligent reporting is unknown, although there are estimates. An earlier review of the literature suggested an 11% to 59% rate for the SOII and a 28% to 75% rate for occupational conditions eligible for workers' compensation coverage[12]. More recent studies, described below, have generated estimates within these ranges. According to Boden and Ozonoffs [28] analysis of six states, the SOII missed 27% - 57% due to willful and negligent underreporting. For Michigan, Rosenman et al [3] estimated that the SOII missed 67.6%. Bonauto et al [29] analyzed data from ten states and found 23% to 53% of cases were missed by the workers compensation system. Lakdawalla, Reville, and Seabury [30] estimated workers compensation missed from 39% to 74% in their most recent years of analysis. These two recent workers compensation studies therefore suggest a range from 23% to 74%. But if workers' compensation systems are more complete than SOII [28,31], then the SOII likely missed more cases than previous estimates suggest.

Following two earlier studies[13,15], we assumed an underreporting rate of 40%. Our sensitivity analysis allowed for a lower bound of 27% and an upper bound of 57% following Boden and Ozonoff[28]. These might be low estimates given that such a high percentage of employees are undocumented. But our estimates assumed that undocumented workers would have reported cases at the same rate (cases/employee) as BLS-SOII workers and the latter are likely to contain a high percentage of documented workers precisely because undocumented workers are less likely to report injuries and illnesses. We assumed, in other words, that undocumented workers reported as frequently as documented workers before we took willful and negligent reporting into account.

The 40% underreporting rate corresponded to a multiplication factor of $1/(1 - 0.4) = 1.667$. For crop farms, the underreporting estimate was $1.667 \times 44{,}959 = 74{,}932$. The same factor was multiplied by the animal farm estimate.

We also conducted a sensitivity analysis in which key assumptions were altered and new estimates were generated. These altered assumptions were included in five scenarios, each with one lower and one upper bound. The first scenario addressed the assumption that farms with <11 employees experienced the same case rate as farms with 11+ employees. This scenario used SOII data on 2011 case rates for farm establishments with 11–49 employees, 50–249 employees, 250–999 employees, 1000+ employees and all sizes combined[32]. The SOII data display an inverted U-shape with establishments with the fewest and greatest number of employees with the lowest rates and establishments with 50–249 and 250–1000 employees with the highest rates. For the lower bound, we used the ratio of rates for establishments with employees 11–49 to the mean rate for all establishments. For crops this ratio was 4.8/5.5[32]. The mean rate for all establishments was in the denominator because it corresponded to our assumption that farms with <11 employees had the same rate as farms with 11+ employees. For the upper bound, the ratio was the highest rate (employees 50–249) to the mean for all establishments. For crops, this ratio was 6.4/5.5. (Calculations are available from the authors.) Because these adjustments were derived directly from injury and illness rates, they did not apply to the QCEW employment multiplication factors of 1.1238 and 1.4096 for crops and animal farms. For example, for the lower-bound for crops, we used 4.8/5.5 = 0.8727 or 87.27% of the original estimate for cases from farms with <11 employees. (For cases from farms with 11+ employees, we did not alter the original estimate). The QCEW employment was 28.38% more than the SOII employment, so the 87.27% was applied to the 28.38% only and the adjustment factor was 1+0.2838×0.8727 = 1. 2477.

The second scenario applied to the assumption that the QCEW missed 14.29% of worker employment and that the adjustment factor was 1/(1–0.149) or 1.1667. This 14.29% was drawn from the 2011 estimate of the QCEW employment undercount. For the second scenario, we used QCEW estimates from 2010 and 2009[33]. In 2010, the estimate was 15.38% and an adjustment factor of 1.1818. In 2009, the estimate was 8.3% and used a multiplication (adjustment) factor of 1.0909.

The third scenario involved the assumption that case rates were the same for farmers and family members as for employees. The preferred estimate above used employment data from the CPS; for example, for CPS crop workers, of the total 966,000 employment, 634,000 were salary and wage workers and the corresponding adjustment factor was 966,000/634,000 = 1.5237. Steven Hipple[34] at the BLS provided us with standard errors and 90% confidence intervals for each CPS mean employment figure. Our interest, however, centered on the ratio of means (i.e. total employment to employee only employment). The standard error of a ratio requires information on the covariance between the numerator and denominator[35]. But we do not have information on the covariance. We therefore applied 90% confidence intervals to numerators and denominators simultaneously. For example, for the upper bound for the ratio for crops, we added the upper limit to 966,000 and subtracted the lower limit from 634,000. For the upper bound for the ratio, we subtracted the upper limit from 966,000 and added the lower limit to 634,000. For the lower bound in crops, for example, the calculation was (966,000 – 59,000)/(634,000 + 48,000) = 1.3299 and 1.3299/1.5237 = 87.28% of the preferred estimate. (All other calculations are available from the authors).

The fourth scenario involved the assumption that applied to willfull or negligent underreporting. We used the 27% and 57% figures in Boden and Ozonoff [28] for lower and upper bounds. These figures correspond to multiplication factors of 1/(1–0.27) = 1/0.73 = 1.3700 and 1/(1–0.57) = 1/0.43 = 2.3256.

Scenario # 5 considered relative standard errors for numbers of recorded injuries and illnesses from the SOII[36]. Relative standard errors are standard errors divided by the corresponding means. We created 90% confidence intervals. For example, the relative standard error for crops was 5.1%. The preferred crop estimates were multiplied by 91.61% (=100% - 1.645 × 5.1%) for the lower bound and 108.39% (=100% + 1.645 × 5.1%) for the upper bound. The relative standard error for animals was 6.4%. The preferred animal estimates were multiplied by 89.47% (=100% - 1.645 × 6.4%) for the lower bound and 110.53% (=100% + 1.645 × 6.4%) for the upper bound.

Results

Table 1 presents findings. The first column indicates the sequential method from beginning with the published SOII data until the final adjustment for willful and negligence underreporting. The second and third columns present numbers that apply to crops and animals, separately; the final column presents numbers that apply to both combined.

Consider row 4. These numbers suggested that simply as a result of the SOII not including farms with <11 employees and the QCEW not counting some farms in some states with <10 employees as well as the QCEW acknowledged underestimate of agricultural industries, we estimated that the SOII captured 19,700/29,507 or 66.8% of injury or illness cases for crop farms, and captured 12,400/20,393 or 60.8%, for animal farms among employees.

Consider row 5. These numbers can be used to estimate the SOII undercount after inclusion of farmers and their family members before applying any adjustment for willful or negligent underreporting. SOII captures 19,700/44,959 = 43.8 % of injury or illness cases on crop farms and 12,400/41,103 = 30.2% for animal farm workers.

Results in the final row indicate, combining crop with animal farms, SOII missed 77.6% of cases. Our preferred estimate was 143,436 cases. Results in the rows 2–5 correspond to causes of the undercount that BLS readily acknowledges. Results from row 6 correspond to willful and negligent underreporting. Estimates from rows 2–5 account for (86,062 – 32,100 = 53,962) 53,962 (53,962/(143,436 – 32,100= 48.5%) or 48.5% of the undercount and estimates from row 6 account for (143,436 – 86,062 = 57,374) 57,374 or 51.5% of the undercount.

Results from this final row also estimate that there was more undercounting in animal (81.9%) than crop production (73.7%). This difference was the result of the larger multiplication factors for animal than crop production in the QCEW adjustment for farms with < 11 employees (1.4096 versus 1.2838) and the CPS adjustment for farmers and family members (2.1056 versus 1.5237).

Table 2 presents results from the sensitivity analysis. Five scenarios with two bounds each are listed in the first column. The three remaining columns list the estimates in crop, animal, and combined farms. The first scenario lower bound, crop farms for example, allowed that injury and illness rates on small farms to be only 87.27% of rather than equal to the SOII rates. The numbers in the final column of the first row indicate that for this scenario, lower bound, the new estimate for numbers of cases for both crop and animal farms combined was 138,060, corresponding to SOII missing 76.75% of injury or illness cases ((138,060 – 32,100))/138,060= 76.75%) and 3.75% less than the preferred estimate of 143,436 cases. The final rows of Table 2 present results for combining the estimates from all five scenarios. For example, for the second column of numbers, crops, lower bound, 19,700 × 1.2477 × 1.0909 × 1.3299 × 1.3700 × 0.9161= 44,752. Combining both crops and animal farms, the lower bound estimate was 83,358 cases, which was 41.88% below the preferred estimate; the upper bound was 273,849 cases, or 90.92% above the preferred estimate.

Discussion

Our approach estimated the undercount of nonfatal occupational injuries and illnesses on crop and animal farms utilizing data from the SOII, QCEW, CPS and assumptions from the literature. Whereas the SOII estimated 32,100 cases in 2011, we estimated 143,436, indicating that SOII missed 77.6%. A sensitivity analysis suggested the percent missed by SOII ranged from 61.5% to 88.3%. The reasons for this undercount are straightforward, and, for the most part, readily acknowledged by BLS. We refer to these as institutional causes of the undercount. First, the SOII explicitly excludes farms with < 11 employees, all self-employed farmers and family members. Second, SOII, QCEW, and CPS acknowledge data-gathering problems from agriculture due to the transient nature of the work and the extent of employment accounted for by undocumented workers. These institutional causes account for nearly one-half of the undercount. Third, there is considerable evidence that workers and employers in all industries underreport cases due to willfulness and negligence[1,13,28–31]. This third cause, which we label behavioral, accounts for a little over one-half of the undercount.

The QCEW is not the only data set with information on agricultural employment; the CPS and the Census of Agriculture also generate estimates. We preferred the QCEW because it serves as the basis for estimates in the SOII. It is nevertheless useful to compare employment estimates. The QCEW estimates 532,245 and 230,610 employees for crop and animal farms, respectively in 2011. In the Current Population Survey for 2011, for private sector employees, these numbers were 626,000 for crop farms and 447,000 for animal. Daniel Carroll[37] recently analyzed Census of Agriculture data from 2007 and estimated 1,358,020 farm workers on crop farms and 434,953 on animal farms. But none of these estimates are for FTEs, and agriculture is well-known for transient and part-time work. Thus, each of these data sets, including the QCEW, have deficiencies[38]. The CPS and Census of Agriculture data suggest an employment undercount by the QCEW. Accordingly, our estimates accounted for an estimated 14.29% employment undercount by the QCEW. Also, and more importantly, we only used ratios from the QCEW to adjust numbers of injury and illness cases from the SOII, and these ratios are similar for all three data sets (QCEW,

CPS and Census of Agriculture). In addition, if the QCEW undercount bias is the same for farms with fewer than and more than 11 employees, then these ratios were appropriate.

Our findings can be compared to others in the literature. Leigh et al[13] found that for all industries combined, the SOII missed between 33% and 69% of cases with the preferred estimate being 45%. Findings in other studies as well as those summarized in Leigh et al[12] suggest undercounting percents from 11% to 75%[1,28–31]. Our higher estimates for agriculture are consistent with the unique SOII exclusions and the inherent undercounts of employment in agriculture. Using SOII fatality data in 1990 and CFOI fatality data in 1992, Leigh et al estimate that SOII missed 79% of cases in agriculture in the 1990s[39].

Most studies suggest that the smaller the firm, the higher the injury rate, but these studies are predominately outside of agriculture and frequently from other countries[40–42]. Data from the SOII, however, suggest that the smaller the establishment size, the smaller the injury rate[43]. Our sensitivity analysis allowed for both lower and higher rates in scenario #1.

We assumed that farmers and family members experienced the same rate of injury and illness (cases-per-number-employed) as employees on farms with >11 employees. This might be an underestimate for farmers because self-employed persons may take more risks than employees; the fatality rate for the self-employed is considerably higher than for employees both on and off farms[44]. It may be an underestimate for family members as the farmer may not let family members be exposed to as much risk or take as many chances as either the farmer him or herself or a paid employee. For these reasons, we chose alternative assumptions in the sensitivity analysis.

Limitations of our study include undercounting assumptions that were not addressed in the sensitivity analysis. The first was the assumption that the QCEW missed 14.29% of employment in agriculture. This 14.29% technically applied to the broad agricultural division --- crops, animals, logging, fishing, hunting, and support services combined--- but we assumed it applied to crop and animal farms. Crops and animals comprised approximately 70% of total employment in the broad agriculture division in 2011 [45]. The second was the assumption of the same 40% underreporting rate due to willfulness and negligence for both crop and animal production. In reality, these may differ just as we estimated the overall undercount to differ between crop (73.7%) and animal (81.9%) production. Finally, it is possible that other researchers may generate alternative estimates using a different methodology. But if that methodology involves using BLS estimates, each of the problems addressed in this paper will have to be addressed by other researchers. We believe that Table 1 presents an indication of the amount of undercount that might occur due to the way the BLS's statistics are gathered and presented.

The substantial undercount of employment and injuries has several baleful consequences for individuals and society. Most fundamentally, undercounting reduces our ability to identify and address agricultural health problems in a large population of workers. The burden falls most directly on undercounted workers, who may fail to benefit from protective governmental programs, such as unemployment insurance and workers' compensation. While unemployment insurance protects workers from economic risk associated with

insecure employment, workers compensation mitigates health and economic risks by providing care and a measure of income replacement for workers injured on the job. Undercounting of employment and occupational health conditions affects society as a whole when the costs of injury and unemployment devolve to other social programs, such as Social Security, Medicare, Medicaid, or charity care. Lastly, undercount limits our ability to identify areas in which preventive measures should be focused.

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Table 1.

Preferred estimates for employment and reportable injury and illness cases

Data sets, procedures, descriptions	Statistics, percentages, and numbers of cases of non-fatal injuries and illnesses		
	Crops	Animals	Total
1. SOII, farms 11+ employees only	Reported cases = 19,700 Employment= 413,800	Reported cases= 12,400 Employment= 163,600	Summed reported cases= 32,100 Summed employment= 577,400
2. QCEW, employees only	Employment= 531,245	Employment= 230,610	Summed employment= 761,855
3. QCEW, upward adjustment of cases reflecting inclusion of farms with <11 employees	Adjustment factor: 531,245/413,800 = 1.2838 times 19,400 yields adjusted cases= 25,291	Adjustment factor: 230,610/163,600 = 1.4096 times 12,400 yields adjusted cases=17,479	Summed adjusted cases= 42,770
4. QCEW, upward adjustment for general agriculture employment undercount of 0.2 million out of 1.4 million total	Adjustment factor: 1.4 million/1.2 million = 1.1667 times 25,291 yields adjusted cases=29,507	Adjustment factor: 1.4 million/1.2 million = 1.1667 times 17,479 yields adjusted cases=20,393	Summed adjusted cases= 49,900
5. CPS, upward adjustment reflecting inclusion of farm owners (farmers) and family members	Adjustment factor: 966,000/634,000 = 1.5237 times 29,507 yields adjusted cases= 44,959	Adjustment factor: 907,000/450,000 = 2.0156 times 20,393 yields Adjusted cases= 41,103	Summed adjusted cases= 86,062
6. Adjustment for underreporting of 40% due to willfulness and negligence	Adjustment factor: 1/0.6 = 1.6667 times 44,959 yields total adjusted cases = 74,932	Adjustment factor: 1/0.6 = 1.6667 times 41,103 yields Total adjusted cases = 68,504	Total summed adjusted cases = 143,436
Percent of cases missed by SOII (total adjusted cases - reported cases)/total adjusted cases	73.7%	81.9%	77.6%

Sources.

1. SOII cases of injury and illness: http://www.bls.gov/iif/oshwc/osh/os/ostb3193.pdf SOII employment :http://www.bls.gov/iif/oshwc/osh/os/ostb3191.pdf

2 and 3. QCEW employment http://www.bls.gov/cew/ew11table2.pdf

4. QCEW Coverage exclusions: http://www.bls.gov/cew/cewbultn11.htm#Employment

5. CPS employment: Personal communication e-mail from Steven Hipple at BLS, June 21, 2013, unpublished BLS table: " Table 4. Employed and experienced unemployed persons by detailed industry and class of worker, Annual Average 2011"

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Table 2.

Sensitivity analysis employment and reportable injury and illness cases

Source of adjustment	Crop		Animal		Total[2]
	Preferred adjustment factor per Table 1, with sensitivity boundaries	Predicted cases for preferred adjustment factor and sensitivity boundaries[1]	Preferred adjustment factor per Table 1, with sensitivity boundaries	Predicted cases for preferred adjustment factor and sensitivity boundaries[1]	
SOII reported cases, with no adjustments		19,700		12,400	32,100
1. QCEW, upward adjustment of cases reflecting inclusion of farms with <11 employees	100%: 1.2838	100%: 74,932	100%: 1.4096	100%: 68,504	100%: 143,436
	87.27%: 1.2477	87.27%: 72,823	83.58%: 1.3575	83.58%: 65,236	Lower: 138,060
	116.36%: 1.3423	116.36%: 77,643	134.33%: 1.5502	134.33%: 75,338	Upper: 152,980
2. QCEW, upward adjustment for general agriculture employment undercount of 0.2 million out of 1.4 million total (14.3%)	14.29%: 1.1667	14.29%: 74,932	14.29%: 1.1667	14.29%: 68,504	14.29%: 143,436
	8.30% : 1.0909	8.30%: 70,064	8.30% : 1.0909	8.30%: 64,054	Lower: 134,118
	15.38%: 1.1818	15.38%: 75,903	15.38%: 1.1818	15.38% 69,392	Upper: 145,295
3. CPS, upward adjustment reflecting inclusion of farm owners (farmers) and family members.	100%: 1.5237	100%: 74,932	100%: 2.0156	100%: 68,504	100%: 143,436
	87.28%: 1.3299	87.28%: 65,404	86.06%: 1.7347	86.06%: 58,959	Lower: 124,362
	114.79%: 1.7491	114.79%: 86,021	116.65%: 2.3512	116.65%: 79,913	Upper: 165,394
4. Adjustment for underreporting of 40% due to willfulness and negligence	40%: 1.6667	40%: 74,932	40%: 1.6667	40%: 68,504	40%: 143,436
	27%: 1.3700	27%: 61,588	27%: 1.3700	27%: 56,305	Lower: 117,893
	57%: 2.3256	57%: 104,556	57%: 2.3256	57%: 95,588	Upper: 200,144
5. Adjustment for SOII relative standard errors for numbers of cases	100%	100%: 74,932	100%	100%: 68,504	100%: 143,436
	91.61%	91.61%: 68,645	89.47%	89.47%: 61,292	Lower: 129,938
	108.39%	108.39%: 81,218	110.53%	110.53%: 75,717	Upper: 156,935
Predicted cases using upper and lower boundaries for all five adjustment factors, (Percent of cases missed by SOII = (total adjusted cases - reported cases)/total adjusted cases)		Lower: 44,752 (55.98%)		Lower: 38,607 (67.88%)	Lower: 83,358 (61.49%)
		Upper: 136,553 (85.57%)		Upper: 137,296 (90.97%)	Upper: 273,849 (88.28%)

[1]The predicted cases shown account for a adjustment factors within scenarios, first using the preferred values followed by the lower and upper boundary values for the adjustment factors.

[2].Horizontal lines may not sum due to rounding.