

ECONOMIC IMPACTS AND FOOD SAFETY IMPLICATIONS OF THE 2022 AND 2023 STRAWBERRY-ASSOCIATED OUTBREAKS JUNE 2026

Disclaimer

This document analyzes the economic impacts on California strawberry producers stemming from the 2022 and 2023 Hepatitis A outbreaks associated with strawberries. It is intended for informational purposes only. Readers should periodically evaluate the applicability of any recommendations in light of their particular circumstances. The authors, contributors, and reviewers make no claims or warranties regarding any specific actions contained herein. This document is designed to facilitate inquiry and develop information that must be independently evaluated by all parties with respect to compliance with applicable legal and regulatory requirements. The providers of this document do not certify compliance and do not endorse any companies or products based on their use of the information contained herein.



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INTRODUCTION

This analysis investigates the economic impacts of the strawberry industry's 2022 and 2023 Hepatitis A outbreaks on California strawberry producers. The analysis determined that in the immediate aftermath of the 2022 outbreak, announced in late May 2022, California strawberry growers experienced an estimated \$125 million in losses due to a short-term negative demand shock. However, for domestic growers, the long-term economic impact from the outbreaks have been minimal. For frozen berry processors, long-term impacts have been greater and stem from changes regarding food safety protocols.

STRAWBERRY INDUSTRY AT A GLANCE

In 2025, the value of U.S. strawberry production reached over \$4 billion for the first time, hitting \$4.4 billion. Strawberry consumption has steadily risen on both a per capita basis and as an overall share of American's diets. Consuming strawberries has many health benefits: they are lower in calories and sugar than other popular fruits, such as apples and oranges, and are high in fiber, vitamin C, antioxidants, and several other vitamins and minerals.¹

Domestic production of strawberries is dominated by California (90% of volume) and Florida (10%). While domestic production, particularly in California, has increased over the past two decades, imports to the United States (U.S.) have grown at a faster rate.

Table 1. U.S. Strawberry Supply Summary: 20-Year Snapshot

	2002-04	2022-24 Annual Avg.	Percent Change
Total U.S. Production (including processed berries)	2.1 billion lbs.	3.0 billion lbs.	+43%
U.S. Fresh Strawberry Supply			
Production	1.3 billion lbs.	2.4 billion lbs.	+91%
Imports	Imports	579 million lbs.	+533%
Import Share of Availability	8%	22%	+177%
Exports	178 million lbs.	311 million lbs.	+74%
Per-Capita Availability	4.0 lbs.	8.0 lbs.	+97%

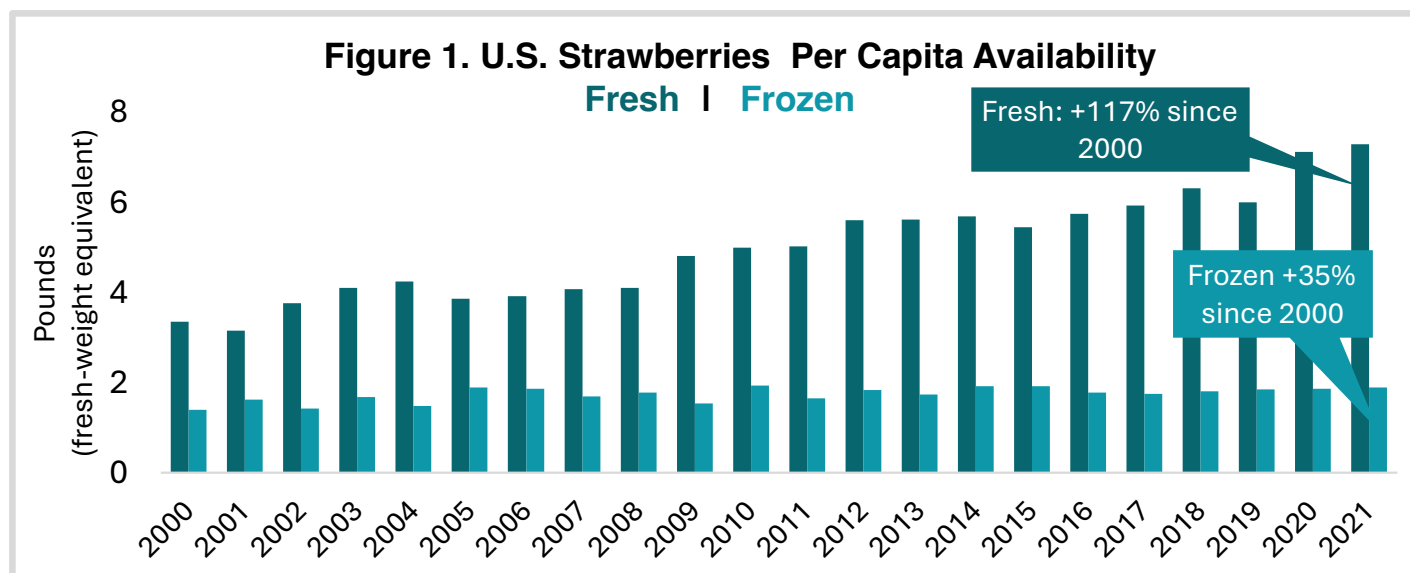
Source: USDA NASS Fruit and Tree Yearbook, Tables D8 and G14, published 2.10.26

¹ Keri Wiginton via WebMD, Health Benefits of Strawberries. <https://www.webmd.com/diet/health-benefits-strawberry>. Accessed 10/09/2025

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Fresh and Frozen Markets

Fresh strawberry consumption has grown faster than frozen consumption over the past several decades, driven by improved supply chains, year-round availability through trade, and consumer preference. Fresh strawberries have a short shelf life, lasting only 1-2 weeks even when treated with immediate cooling after harvest.² Because fresh strawberries cannot be stored, prices fluctuate widely in response to seasonal changes in supply and demand.



Source: USDA ERS Food Availability (Per Capita) Data System

Over time, domestic production has shifted more towards the fresh market. In the early 2000s, around 30% of California strawberries went to the processing market, typically as frozen product. In more recent years, the percentage has dropped by about one third to around 20%. In 2023, due to floods restricting strawberry production, the California strawberry industry saw a record low 12.9% (292 million pounds) of its crop go to processing.³ The decline continued in 2024, falling to 12.2% (310 million pounds), before rebounding slightly to 14.6% (364 million pounds) in 2025.⁴ The fresh market is the primary market for domestic growers as it is more profitable.⁵

² USDA ERS – The Changing Landscape of U.S. Strawberry and Blueberry Markets: Production, Trade, and Challenges from 2000 to 2020. <https://www.ers.usda.gov/sites/default/files/laserfiche/publications/107358/EIB-257.pdf?v=37417>

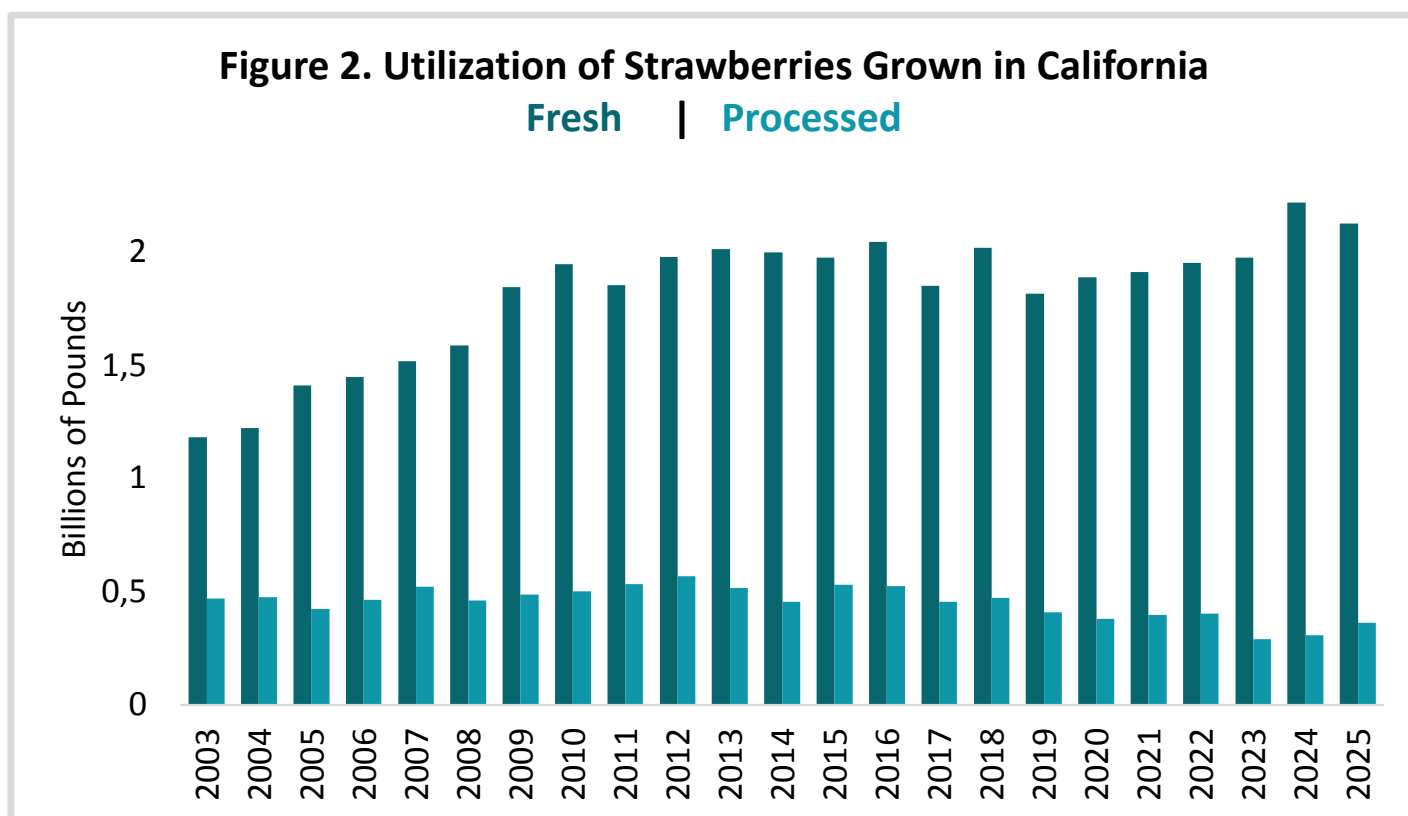
³ California Department of Agriculture – Annual Report on Price Postings for Processing Strawberries, 2023 Marketing Season. https://www.cdfa.ca.gov/mkt/mkt/documents/annual_reports/2023_price_posting_report_with_appendices.pdf

⁴ Processing Strawberry Advisory Board of California – 2025 Annual Report.

⁵ Yeh, D.A., Kramer, J., Calvin, L., & Weber, C. (2023). The changing landscape of U.S. strawberry and blueberry markets: Production, trade, and challenges from 2000 to 2020 (Report No. EIB-257). U.S. Department of Agriculture, Economic Research Service. <https://doi.org/10.32747/2023.8134359.ers>

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Strawberries are planted once, then harvested frequently once the plants enter production, up to every three days during peak season. Domestically grown strawberries that end up being processed typically faced impediments to the fresh market, such as not meeting certain grade requirements due to quality issues, market restrictions, or an oversupply of fresh-market strawberries. Utilization of California-grown strawberries by market segment is demonstrated in Figure 2. While selling strawberries for processing is viewed as economically sub-optimal by strawberry growers, it remains an important secondary market that growers can leverage to recoup input costs when they find themselves with lower-grade crops or at times of oversupply.



Source: Processing Strawberry Advisory Board 2025 Report, processed includes berries utilized for frozen and juice

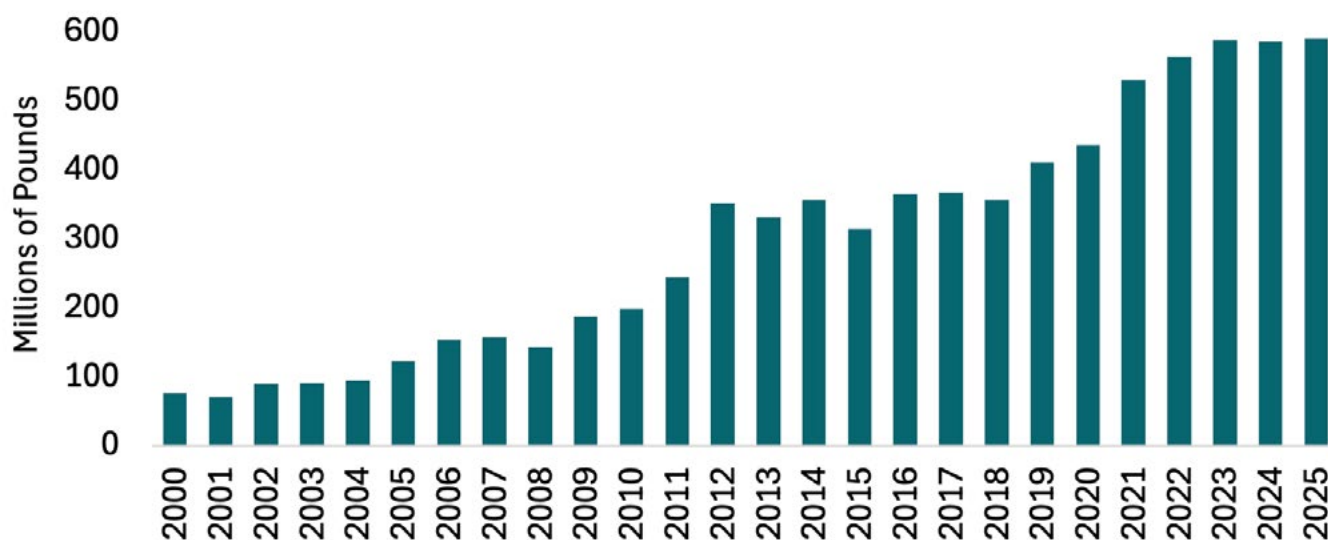
Imports

Over the past two decades, the quantity of strawberries imported has increased. Imports fall into three primary buckets: fresh strawberries bound for the fresh market, fresh strawberries that are later processed (typically frozen, predominantly in California), and frozen strawberries.

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Fresh strawberry imports have steadily increased over time and are almost exclusively from Mexico. In fact, Mexico has accounted for 99% of all fresh strawberry imports by the U.S. since 2000. While imports of fresh strawberries have grown considerably over the past 25 years, since 2023 they have plateaued. In 2025, fresh strawberry imports accounted for 74% of strawberry imports by value (\$1 billion) while frozen strawberries accounted for 26% (\$361 million). While not directly comparable by weight, in 2025, fresh strawberry imports for the fresh market were 510 million pounds, fresh strawberry imports for the processed market were 80 million pounds, and frozen strawberries imports were 387 million pounds.

Figure 3. U.S. Imports of Fresh Strawberries



Source: U.S. Census Bureau via USDA GATS. Depicts fresh strawberry imports from HS Code 0810.10. Includes fresh strawberries imported to be further processed in the U.S.

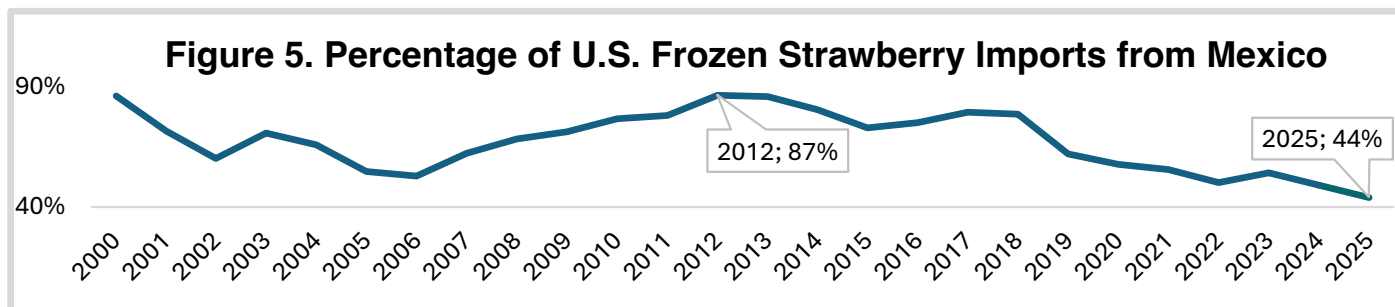
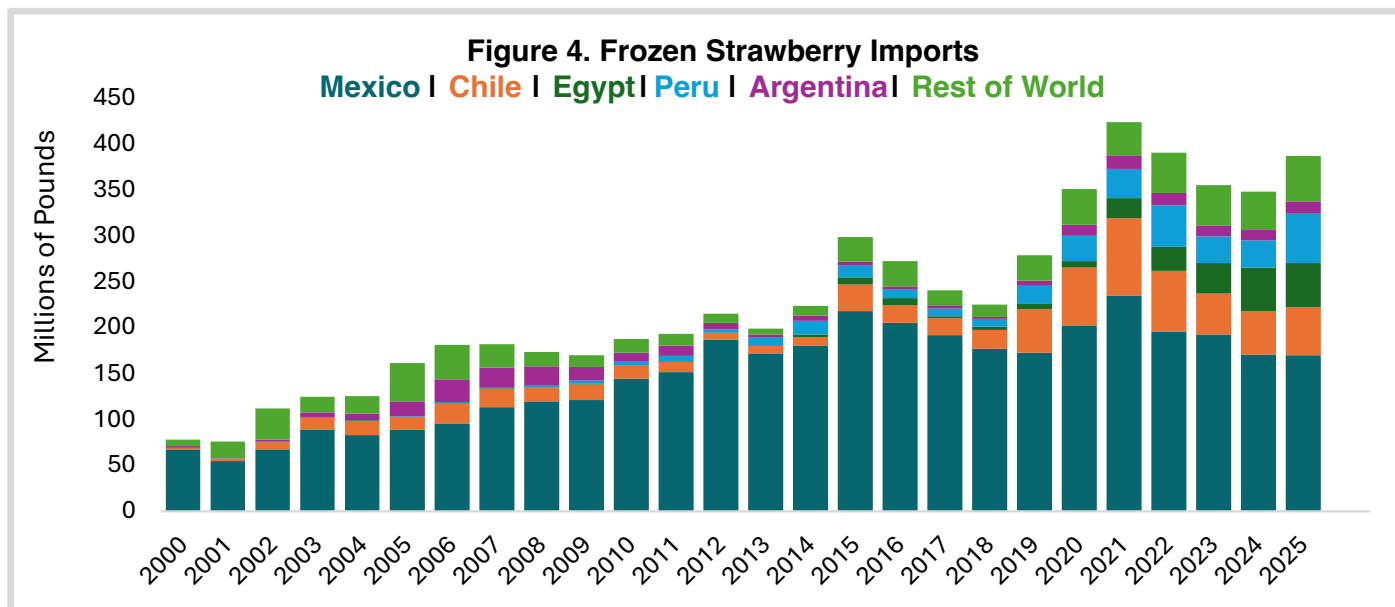
Between 2021-2025, an average of 22% of strawberries processed in California were imported fresh from Baja California, Mexico. The percentage of strawberries sourced from growers in Baja and processed in California peaked in 2023 at 25% (97.5 million pounds) but fell to 18% (79.8 million pounds) by 2025. Based on data reported by the Processing Strawberry Advisory Board, which began breaking out processing berries imported from Baja in 2014 and import data from the U.S. Census Bureau via USDA GATS, the percentage of fresh strawberries imported from Mexico that are used for processing in California has consistently fallen from a high of 26% in 2014 down to 14% in 2025.

While some frozen strawberries are initially imported as fresh produce and then frozen by processors, a majority are imported already frozen. Imports of frozen strawberries peaked in 2021 at 423.8 million pounds, increasing 443% since 2000. From their all-time high in 2021, frozen strawberry imports dropped 18% to 348.3 million pounds by 2024 (Figure 4). In 2025, the downward trend reversed with an increase to 387.3 million pounds.

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While frozen strawberry imports have been dominated by Mexico, which has accounted for 66% of total U.S. imports since 2000, supplies among importing countries fluctuate widely from year-to-year. The percentage of frozen strawberry imports to the U.S. originating in Mexico peaked in 2012 at 87% and hit a low in 2025 at 44% (Figure 5).



Source: U.S. Census Bureau via USDA GATS. Depicts frozen strawberry imports from HS Codes 0811.10.0020, 0811.10.0050, 0811.10.0060, 0811.10.0070

State of California Strawberry Economy

The overall American agricultural economy is struggling, suffering from years of stagnant or faltering prices with simultaneously escalating costs. California's strawberry industry is no different. In 2024, the estimated cost to produce strawberries reached approximately \$113,000 per acre, an increase of 18% since 2021.⁶

⁶ UC Davis Cost & Return Studies, Strawberries, Central Coast. 2024 (<https://coststudyfiles.ucdavis.edu/2024/04/04/2024Strawberry-FULL-FINAL-March2024.pdf>), 2021 (<https://coststudyfiles.ucdavis.edu/uploads/pub/2022/01/04/strawberrycentralcoastfinaldraft-121321.pdf>)

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At the same time, revenues have not kept up with increases in costs, further reducing growers' profits and, in many cases, creating a deeper financial hole for growers.

In fact, in Marketing Year (MY) 2024 as compared to MY 2021, the price received for strawberries per hundredweight decreased by 5%, falling from \$125 in 2021 (approximately \$11.25/9 lb tray) to \$119 in 2024 (approximately \$10.71/9 lb tray), according to USDA data. Assuming a yield of 9,000 9-lb trays, these prices would indicate a profit of around \$5,600 per acre in 2021 and a loss of nearly \$16,600 an acre in 2024. If those losses were accurate for all 45,000 acres harvested in California in 2024, it would result in industry-wide losses of approximately \$746 million dollars. While there are variations in individual farm's margins, the overall trend shows that strawberry growers have struggled in the last several years.

HEPATITIS A VIRUS

Hepatitis A (HAV) is a virus mostly impacting the liver that causes fever, malaise, jaundice, loss of appetite, nausea, stomach pain, and dark urine. While symptoms typically last less than two months, up to one in six symptomatic people may have prolonged or relapsing disease for up to six months. HAV rarely causes lasting damage, but liver failure and death can occur in rare cases. The disease is highly contagious and spread by the fecal-oral route, most commonly by either direct contact with an infected person or ingesting contaminated food or drink. In the U.S., HAV is most commonly spread from person to person, not through food. , People at increased risk of HAV in the U.S. include international travelers, men who have sex with men, illegal drug users, people in close personal contact with an international adoptee, and the homeless. HAV has a long incubation period of 15-50 days and is most transmissible in the two weeks prior to the onset of symptoms. The likelihood of experiencing symptoms increases with age, and young children are typically asymptomatic.

Least developed countries with limited infrastructure generally have higher rates of HAV transmission. However, an individual infected with HAV in these countries has lower rates of virus-related adverse health effects, as HAV exposure typically occurs when a person is very young before they would experience symptoms. In countries with low HAV incidence rates, specific HAV occurrences are more likely to cause symptoms (including those leading to hospitalization and death) as exposure typically occurs later in life. A proxy for prevalence of HAV in a country is the estimated age for which half the population has reached immunity to HAV (Figure 6). For countries with high prevalence, people are exposed earlier in life and thus have immunity at a younger age. Imported foods from low- and middle- income countries and travel to countries with higher prevalence of HAV are two common pathways for HAV to spread across borders.¹⁰ In 2025 by value, 98% of U.S. imported strawberries are from countries with a higher prevalence of HAV than the U.S., with 84% of strawberry imports by value coming from Mexico alone.

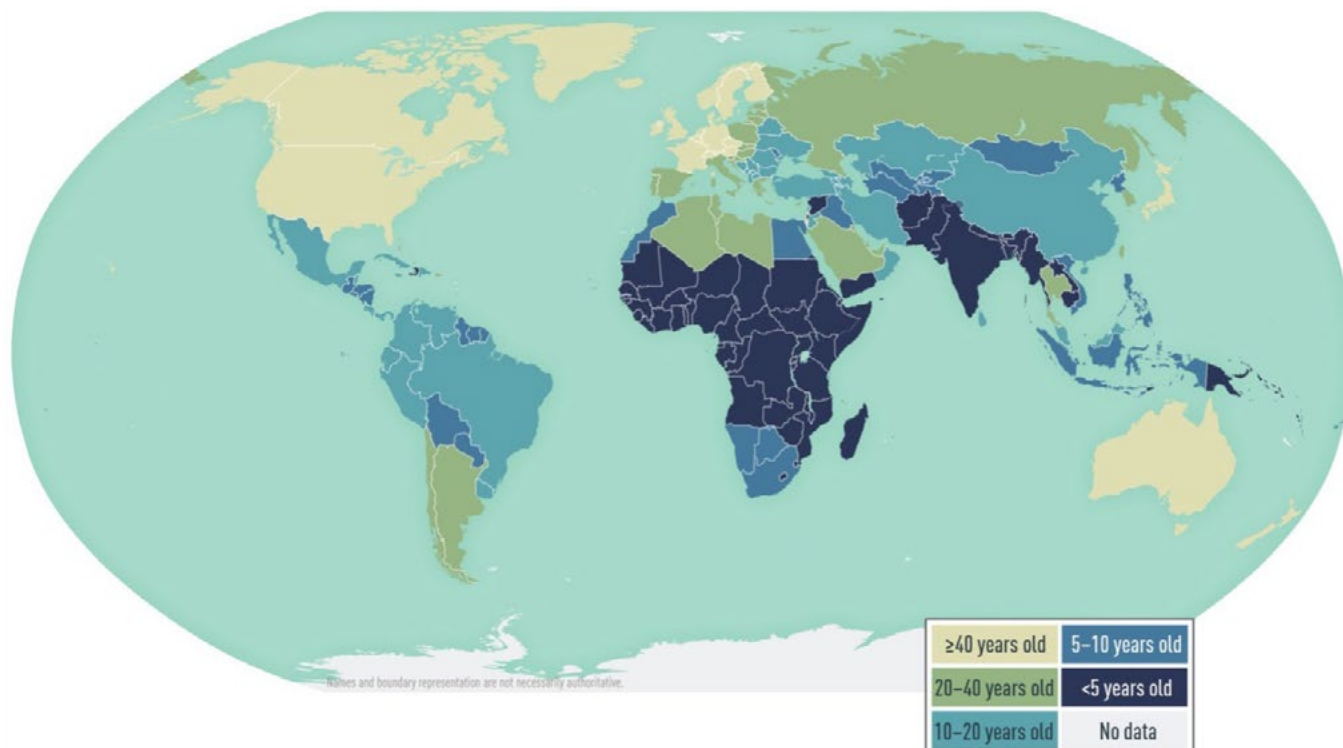
⁷ CDC – Hepatitis A Outbreaks Linked to Person-to-Person Contact. <https://www.cdc.gov/hepatitis-a/outbreaks/person-to-person/index.html>. Accessed October 7, 2025

⁸ Scallan, E., Hoekstra, R.M., Angulo, F.J., Tauxe, R.V., Widdowson, M.-A., Roy, S.L., Jones, J.L. & Griffin, P.M. 2011. Foodborne illness acquired in the United States—Major Pathogens. *Emerging Infectious Diseases*, 17(1): 7–15. <https://doi.org/10.3201/eid1701.P11101>

⁹ Centers for Disease Control and Prevention. *Epidemiology and Prevention of Vaccine-Preventable Diseases*. Hall E., Wodi A.P., Hamborsky J., et al., eds. 14th ed. Washington, D.C. Public Health Foundation, 2021.

¹⁰ Jacobsen, K. H. (2018). Globalization and the changing epidemiology of hepatitis A virus. *Cold Spring Harbor Perspectives in Medicine*, 8(10), a031716.

Figure 6. Estimated age at midpoint of population immunity (AMPI) to hepatitis A, by country



Source: CDC Yellow Book, adapted from Jacobsen, K. H. (2018). Globalization and the changing epidemiology of hepatitis A virus. *Cold Spring Harbor Perspectives in Medicine*, 8(10), a031716.

A vaccine for HAV¹¹ was first approved by the U.S. Food and Drug Administration (FDA) in 1995 for people two years of age and over, and its minimum age was lowered to 12 months in 2005. In March 2006, the Advisory Committee on Immunization Practices (ACIP) added Hepatitis A vaccines to its list of recommendations for the routine vaccination schedule of children ages one and over in the US. Notably, the ACIP does not recommend HepA vaccination for persons who handle food in the absence of other risk factors, meaning that unless they have additional risk factors (such as traveling internationally, using illegal drugs, being around international adoptees, etc.), food handlers are not specifically recommended to seek out a HepA vaccine.¹² Childhood HepA vaccinations have been recommended in California, the country's top strawberry producing state, since [March 1999](#).

¹¹ While the Hepatitis A Virus is typically shortened to the acronym "HAV", its vaccine is typically referred to as the "HepA vaccine."

¹² CDC – Prevention of Hepatitis A Virus Infection in the United States: Recommendations of the Advisory Committee on Immunization Practices, 2020. <http://dx.doi.org/10.15585/mmwr.rr6905a1>.

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Between 1996 and 2011, HAV incidence fell by over 95% in the U.S.¹³ For children born in 2022 and 2024, 79% had received both doses of a HepA vaccine by 35 months.¹⁴ However, of all recommended childhood vaccines, this coverage level ranks above only rotavirus (74%) and influenza (56%).¹⁵ As of January 5, 2026, the [U.S. Center for Disease Control \(CDC\) changed the recommendation status of several childhood immunizations](#), including for HAV, from universally recommended to recommended for certain high-risk children or populations. The HepA vaccine was also placed into a new category of immunizations, with recommendations “based on shared clinical decision-making.” Under a U.S. District Court order issued on March 16, 2026, the CDC’s changes are stayed as of May 1, 2026, following a court order, meaning they are not in effect and cannot be implemented.¹⁶ According to announcements from the CDC, if the changes are implemented, the HepA vaccine would still be required to be covered by both federal and private health insurance providers.

Mexico, which provided 84% of U.S.-imported strawberries by value in 2025, did not approve a HepA vaccine until 2008, and HepA vaccination was not included in the country’s schedule of recommended childhood vaccines until 2026.¹⁷ This also may impact American-grown strawberries, as around 5 of 6 farmworkers in California were born in Mexico.¹⁸ Additionally, since about 80% of hired farm laborers, graders, and sorters are over the age of 25, regardless of where they were born, they are unlikely to be vaccinated for HepA.¹⁹ As of 2021, only 24.8% of adults in the U.S. aged 19 years or older recalled receiving at least one HepA vaccination dose.²⁰

Hepatitis A Outbreaks Related to Food

There have been several notable HAV outbreaks related to food in the U.S. and across the globe. Because HAV is inactivated by heat, HAV food-related outbreaks occur almost exclusively in foods that are uncooked. While HAV can remain transmissible from fresh produce for several days, it can exist for months or longer on frozen foods.^{21 22}

¹³ CDC – Epidemiology and Prevention of Vaccine-Preventable Diseases. Chapter 9: Hepatitis A. 14th edition, published August 2021. <https://www.cdc.gov/pinkbook/hcp/table-of-contents/chapter-9-hepatitis-a.html>.

¹⁴ CDC – Vaccination Coverage by Age 24 Months Among Children Born in 2021 and 2022 – National Immunization Study – Child, United States, 2022 – 2024. <https://www.cdc.gov/mmwr/volumes/75/wr/mm7511a2.htm>. Accessed May 1, 2026.

¹⁵ Ibid.

¹⁶ Congressional Research Service Changes to CDC Vaccine Recommendations in 2025 and 2026. https://www.congress.gov/crs_external_products/IN/PDF/IN12684/IN12684.1.pdf. April 28, 2026.

¹⁷ We were unable to confirm the status or history of HepA vaccine recommendations for adult populations by the Mexican government.

¹⁸ [California Findings from the National Agricultural Workers Survey \(NAWS\) 2015-2019: A Demographic and Employment Profile of California Farmworkers](#)

¹⁹ USDA ERS – Farm Labor – Demographic Characteristics of Hired Farmworkers – analysis of data from the U.S. Department of Commerce, Bureau of the Census, American Community Survey, 2022. <https://www.ers.usda.gov/topics/farm-economy/farm-labor>. Accessed October 9, 2025

²⁰ CDC – Vaccination Coverage among Adults in the United States, National Health Interview Survey, 2021 <https://www.cdc.gov/adultvaxview/publications-resources/vaccination-coverage-adults-2021.html> Accessed October 9, 2025

²¹ Sewlikar, S. & D’Souza, D.H. 2017. Survival of hepatitis A virus and Aichi virus in cranberry-based juices at refrigeration (4 °C). Food Microbiology, 62: 251–255. <https://doi.org/10.1016/j.fm.2016.10.003>

²² Cook, N., Bertrand, I., Gantzer, C., Pinto, R.M. & Bosch, A. 2018. Persistence of hepatitis A virus in fresh produce and production environments, and the effect of disinfection procedures: a review. Food and Environmental Virology, 10(3): 253– 262. <https://doi.org/10.1007/s12560-018-9349-1>

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In 2023, the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO) ranked HAV second as a “foodborne virus of the highest public health concern,” with shellfish, frozen berries, and prepared foods as the most concerning food pathways.²³ Frozen berries were also listed as the second highest commodity for risk of norovirus. The WHO and FAO specifically highlight the pathway of foods imported from countries with high prevalence of HAV to countries with low prevalence of HAV as a primary cause of foodborne HAV outbreaks. When highlighting foods associated with HAV outbreaks between 2013 and 2023, all 15 produce-related outbreaks involved food imported from a lower-socioeconomic status (SES) country to higher-SES countries, which can be a proxy for level of infrastructure and sanitation access linked to levels of HAV prevalence. Of the 19 total HAV outbreaks listed, 9 outbreaks stemmed from frozen berries (47%), 4 from shellfish (21%), 3 from fresh dates (16%), 2 from frozen pomegranate arils (11%), and 1 from fresh blackberries (5%).

Of the 24,729 total recorded U.S. foodborne illness outbreaks between 1998 and 2023, 113 cases (0.5%) were related to HAV.²⁴ Of food-based outbreaks, HAV was responsible for 3,094 total illnesses (0.7%), 507 hospitalizations (2.2%), and 14 deaths (2.6%). The higher percentage of deaths and hospitalizations compared to total illnesses indicates that HAV outbreaks typically result in a disproportionate number of severe cases. Notably, no enteric virus outbreaks (including both norovirus and HAV) in the U.S., have been caused by domestically grown fresh or frozen berries in 35 years.²⁵ The distinction between enteric viruses and other foodborne illnesses, typically transmitted by bacteria, are important because viruses have unique attributes compared to bacteria. For instance, enteric viruses do not multiply in food and are spread primarily through infected food handlers. In addition, the FDA has [developed a prevention strategy for control of enteric viruses in berries](#).

2022 and 2023 Outbreak Related to Imported Strawberries

In 2022 and 2023, two separate HAV disease outbreaks were declared by the CDC.²⁶ Both outbreaks were ultimately traced back to contaminated strawberries from a single farm in Mexico. The first declared outbreak in 2022 was related to fresh organic strawberries which infected 29 people between March 28 and May 6 in the U.S. and Canada. Later, in 2023, 10 people were infected between November 24 and May 27 with Hepatitis A from frozen strawberries.

²³ World Health Organization & Food and Agricultural Organization of the United Nations. 2024. Microbiological Risk Assessment of Viruses in Foods: Part 1: Food Attribution, Analytical Methods, and Indicators: Meeting Report. <https://www.who.int/publications/i/item/9789240101074>.

²⁴ Centers for Disease Control and Prevention (CDC). BEAM (Bacteria, Enterics, Amoeba, and Mycotics) Dashboard. Atlanta, Georgia: U.S. Department of Health and Human Services. www.cdc.gov/ncezid/dfwed/BEAM-dashboard.html. Accessed 10/09/2025.

²⁵ U.S. Food and Drug Administration (FDA). Summary of FDA's Strategy to Prevent Human Norovirus and Hepatitis A Outbreaks Associated with Fresh and Frozen Berries. <https://www.fda.gov/food/new-era-smarter-food-safety/summary-fdas-strategy-prevent-human-norovirus-and-hepatitis-outbreaks-associated-fresh-and-frozen> Accessed 10/09/2025

²⁶ McClure et al. Investigation of Two Outbreaks of Hepatitis A Virus Infections Linked to Fresh and Frozen Strawberries Imported from Mexico – 2022–2023, Journal of Food Protection, Volume 88, Issue 6, 2025, 100505, ISSN 0362-028X, <https://doi.org/10.1016/j.jfp.2025.100505>



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During the initial 2022 investigation, the U.S. FDA and Canadian Food Inspection Agency (CFIA) were able to trace the illness back to strawberries imported from Baja California, Mexico, but did not identify a single grower accountable for all the illnesses. Due to the long incubation time of HAV and short shelf life of fresh strawberries, by the time the outbreak was traced to Baja California, all affected strawberries were past shelf life and imports from the region were over for the season – so no recall was issued. However, on May 28, 2022, the FDA first issued a public health advisory on the outbreak and encouraged consumers to discard organic strawberries from specified brands purchased between March 5 and April 25, 2022, potentially causing broad reputational damage to strawberries in general.

Initial May 28th communications did not include any information on the country of origin of the impacted product. FDA's May 31st update stated that imported fresh organic strawberries were identified as the likely source. Subsequent communication starting on June 1st further clarified that the strawberries were identified as being imported from Baja California, Mexico. On August 14, 2022, the CDC declared the outbreak over.

Each FDA communication regarding the 2022 outbreak stated, "People who purchased FreshKampo and HEB fresh organic strawberries between March 5, 2022 and April 25, 2022, and then froze those strawberries for later consumption should not eat them." Even though any fresh strawberries that were purchased during the window of concern would have spoiled by the time the FDA communication was released, the FDA still chose to release the notice because of concern that individual consumers may have frozen infected strawberries at home for later use.

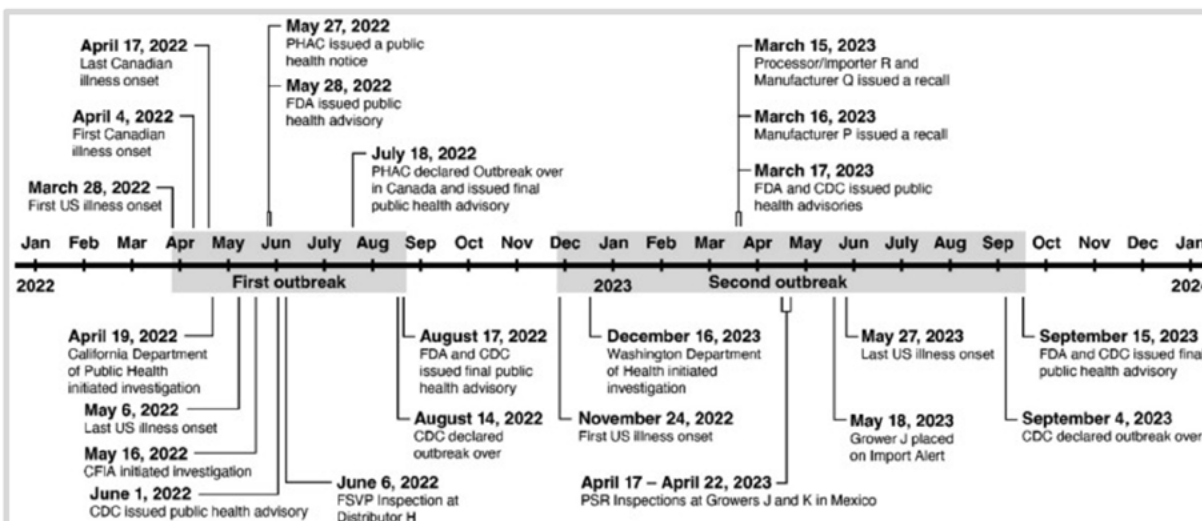
However, at the time of the 2022 outbreak, the U.S. FDA did not investigate if fresh produce suspected in the outbreak had also entered the formal frozen market – which they later recognized should have been a "standard practice."²⁷ Because the frozen strawberry pathway was not investigated fully, strawberries from Baja California, Mexico – including those from the source farm – were comingled with other strawberries and eventually other frozen fruit. Since the product was thoroughly comingled, it could not be traced precisely – leading to a large-scale recall of frozen strawberries and mixed fruit blends. In the end, even though the problematic imported strawberries came from just one farm in Mexico and were sent to one primary distributor in California, the recalled products affected four food manufacturers, ultimately impacting nine total brands and 12 unique products. Recalls from the 2023 outbreak began on March 15th with the FDA and CDC announcing public health advisories on March 17th. The outbreak was declared over by the CDC on September 4, 2023. A total of 10 recorded illnesses stemming from the second, frozen-strawberry-related outbreak ranged from November 24, 2022 to May 27, 2023.

²⁷ Ibid., 6.

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Figure 7. Timeline of the 2022 and 2023 HAV Outbreaks from Strawberries



Source: McClure, Monica, et al. "Investigation of Two Outbreaks of Hepatitis A Virus Infections Linked to Fresh and Frozen Strawberries Imported from Mexico–2022–2023." *Journal of Food Protection* 88.6 (2025): 100505.

ECONOMIC COSTS OF 2022 AND 2023 OUTBREAKS TO DOMESTIC STRAWBERRY INDUSTRY

To capture the economic cost to domestic strawberry growers and industry, a series of interviews with frozen berry processors, growers, and strawberry industry representatives were conducted in Spring 2026.²⁸ While anecdotal, the interviews told a consistent story regarding the shape and scope of the economic impact from the 2022 and 2023 outbreaks, which aligned with publicly available data. On net, the domestic strawberry industry saw an intense drop in demand immediately following the 2022 outbreak as reflected in fresh strawberry wholesale prices, but consumer interest recovered within a few weeks. Frozen berry processors have experienced increased costs related to food safety protocols, such as additional enteric virus testing, increased due diligence regarding the farm-level safety measures of all sourced berries, and increased product tracing. At this time, additional ongoing costs for domestic growers related to increased food safety protocols appears minimal.

Growers

For growers, domestic impacts were primarily concentrated in the initial price decreases related to the 2022 outbreak. Price declines were almost exclusively driven by declines in demand for strawberries related to consumer awareness of safety concerns. No strawberries were recalled in 2022, and strawberry fields are planted at the beginning of the season and harvested continuously indicating that price declines were unrelated to outbreak-related supply shocks. Price declines structurally fell on the shoulders of California growers. The Saturday of Memorial Day weekend, which is when the outbreak announcement was released by the FDA, typically kicks off peak strawberry season for California growers, who at that point in the season are the sole supplier of fresh strawberries in the U.S. market.

²⁸ Interviews were limited in quantity. In total, interviews were conducted with two organic strawberry growers, two current or former frozen berry processor food safety officers, and one strawberry industry representative.

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Based off common contract structures between growers and shippers, growers also generally incurred a majority of the economic losses related to price declines. Interviewed growers shared that contracts with shippers, who market the strawberries and bring them to retail, generally consist of fixed fees for cooling and packaging, and a set percentage commission for the sale of the berries. As the total fee paid to shippers consists of both fixed and percentage-based costs, declines in prices are disproportionately felt by the grower, as demonstrated in a hypothetical example below in Table 2.

Table 2. Hypothetical Example of Strawberry Price Decline Impact

Unit: \$/Tray	Pre-Price Drop	Post-Price Drop	Percent Change
Wholesale Price	\$20	\$12	-40%
Packaging Fee	\$2.15	\$2.15	Fixed Fee - No Change
Cooling Fee	\$0.58	\$0.58	Fixed Fee - No Change
Commission (8%)	\$1.60	\$0.96	-40%
Shipper's Revenue	\$4.33	\$3.69	-15%
Grower's Revenue	\$15.67	\$8.31	-47%

Source: Hypothetical contract structure between a grower and shipper based on interviews with California strawberry growers. Prices in this example are nominal and fall within a reasonable range of possible prices that growers/shippers might experience. Some shippers have a floating commission fee structure.

Interviews with growers and industry representatives revealed that, in years prior to the 2022 outbreak, domestic growers had already implemented best practices for enteric virus prevention, including accessible restroom facilities near fields and strict hand-washing protocols. While growers may be putting greater emphasis on prevention of enteric viruses because of the outbreaks, California growers didn't have to implement any significant changes to their food safety programs since they were already industry leaders in food safety practices. Thus, California growers have faced little additional economic cost from increased food safety protocols to date.

Lastly, postharvest testing for enteric viruses like HAV, which has become increasingly common in frozen berries in response to the outbreak, is not conducted on fresh berries according to the interviewees. Each interview emphasized that testing on fresh berries would prove impractical with the tight supply chain timeline of a highly perishable product like strawberries.

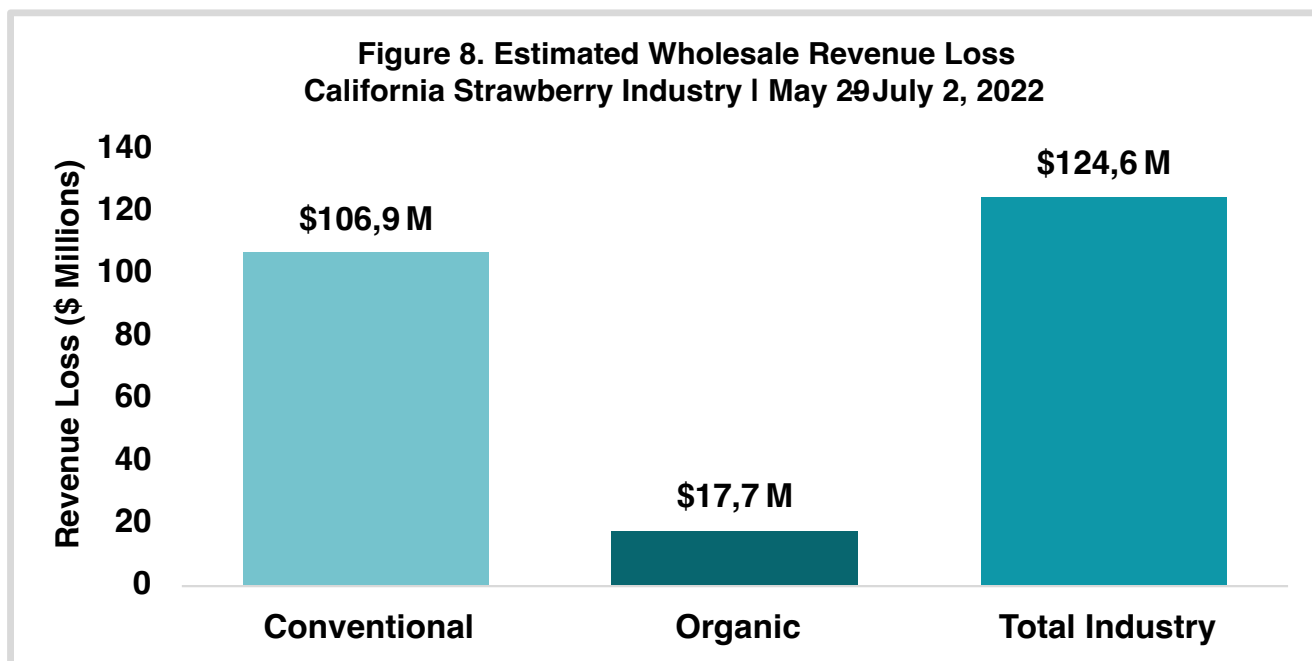
Statistical Analysis: Price Impacts of 2022 Outbreak on Shipping Point Prices of Fresh Strawberries

The 2022 outbreak was announced nationally via public health advisories from the FDA and CDC between the dates of May 28 and August 14, which fall squarely in the months where California-grown strawberries dominate U.S. domestic supply. To assess the economic damage from price declines during the 2022 outbreak, an interrupted time series event study analysis with fixed effects was carried out, which estimates price impacts for both organic and conventional California strawberries. The analysis uses weekly USDA AMS wholesale data from 2016 to 2025, compiled by the California Strawberry Commission's Custom District Reports.

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The model controls for supply (weekly trays sold), year-level macroeconomic trends, and week-of-year seasonal patterns using fixed effect controls, isolating price deviations during the five weeks following the May 28th announcement.²⁹

In the five weeks following the FDA's announcement, the California strawberry industry experienced estimated revenue losses of approximately \$125 million from declining FOB prices alone.³⁰ The conventional strawberry market, which accounted for approximately 90% of production by volume and 88% by value in 2022, faced an estimated \$107 million in losses, while organic growers faced \$18 million in losses. These loss estimates represent 5.4% of 2022 annual revenue from fresh organic strawberries and 4.5% for conventionally grown strawberries.



The dollar amounts are reflective of a price decline of approximately 27% to 29% from the expected price during the five-week window for both conventional and organic strawberries. The fact that the price decline percentages were nearly identical indicates that the organic strawberries did not see a disproportionate decline in demand, even though HAV outbreak was limited to only organic strawberries. Instead, the outbreak announcement triggered a category-wide consumer response that depressed all strawberry prices equally.

²⁹ The model equation is $\ln P_t = \alpha + \alpha(\text{Acute5wkt}) + \alpha(\ln St) + \alpha_y + \alpha_w + \alpha_t$, where Acute5wkt equals one for the five weeks following the May 28, 2022 announcement (encompassing May 29 – July 2, 2022) and zero otherwise; $\ln St$ controls for weekly supply; and α_y and α_w are year and week-of-year fixed effects, respectively. Standard errors are calculated using the Newey-West correction, which is robust to heteroskedasticity and autocorrelation. Primary results are statistically significant at the $p < 0.001$ level.

³⁰ Revenue losses are calculated by converting the estimated log-price effects into percentage price effects and applying those effects to observed wholesale revenue during the acute period. Because the model controls for annual and seasonal price patterns and supply levels but does not include a fully unaffected control group, the estimates should be interpreted as event-associated wholesale revenue losses rather than definitive causal losses. As an additional robustness check, I calculated revenue losses using a week-by-week event study specification, rather than a single five-week average. This approach produced a smaller, but directionally consistent estimate of approximately \$86 million. Because week-specific coefficients are more sensitive to noise in individual weekly observations, the five-week average specification is used as a primary estimate.

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The price declines stemming from the announcement were sharp, but temporary. FOB prices fell immediately following the announcement, hitting a low point in weeks 2 and 3, then returned to baseline by week 6. Extending the impact window from 5 to 13 weeks resulted in a price effect that was statistically insignificant, again confirming that the demand shock was short-term. This timing aligns with Google Trends data regarding interest in strawberries, which can serve as general proxy of overall consumer interest in the outbreak.

Interest in the search term “strawberries” for 2022, as depicted in Table 3 and Figures 9 and 10, peaked in the week following the outbreak announcement. The week of Valentine’s Day saw the second highest amount of search traffic, but with only 59% of the searches compared to the outbreak week. While typical top query terms for strawberries throughout the course of the year involve topics unrelated to virus outbreaks, such as “chocolate strawberries” or “dogs eat strawberries,” in the week following the May 28th announcement, 9 of the 10 top search terms and more than 75% of top 50 search terms related to strawberries directly involving the outbreak in some way (e.g., “strawberry hepatitis,” “heb strawberries,” “fda strawberries” or “strawberries recall”).

Browser searches related to the HAV outbreak or recall strawberries remained within top 50 strawberry-related searches through the end of June 2022 but fell off quickly from the top strawberry-related searches in the weeks following the announcement (Figure 11).

**Table 3. Google Trends Web Searches Top Queries
Ranking of First Outbreak Related Search Term for Strawberries**

	Weeks After Announcement	Highest Ranking
May 28 – June 3	1	1st
June 4 - 10	2	5th
June 11 - 17	3	15th
June 18 - 24	4	32nd
June 25 – July 1	5	47th
July 2 - 8	6	No outbreak-related search terms among top 50 queries

Source: Google Trends Web Search. Geography: United States

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Figure 9. Google Trends
"Strawberries" | Weekly | 2022

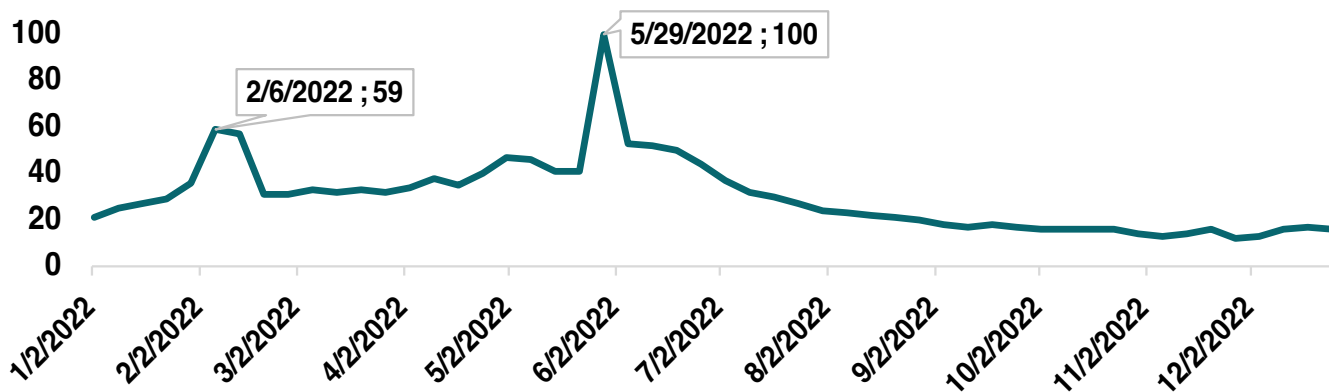
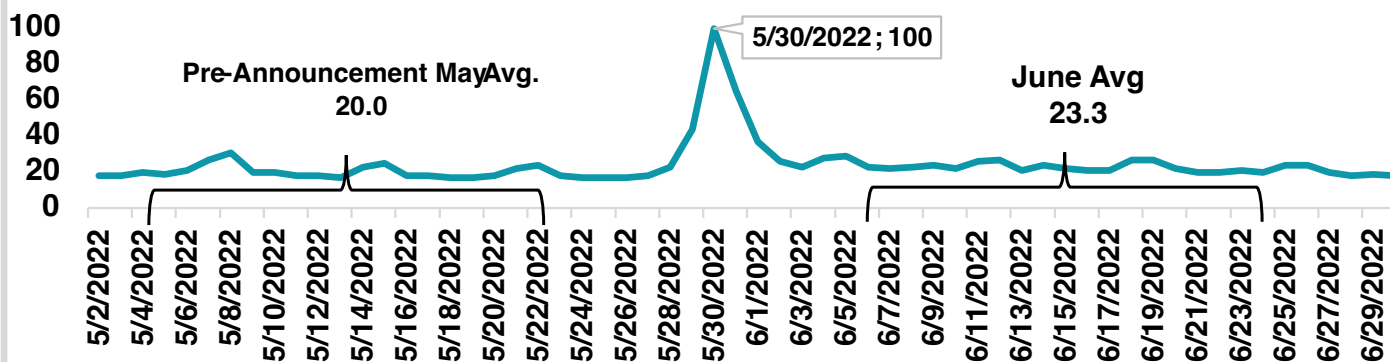
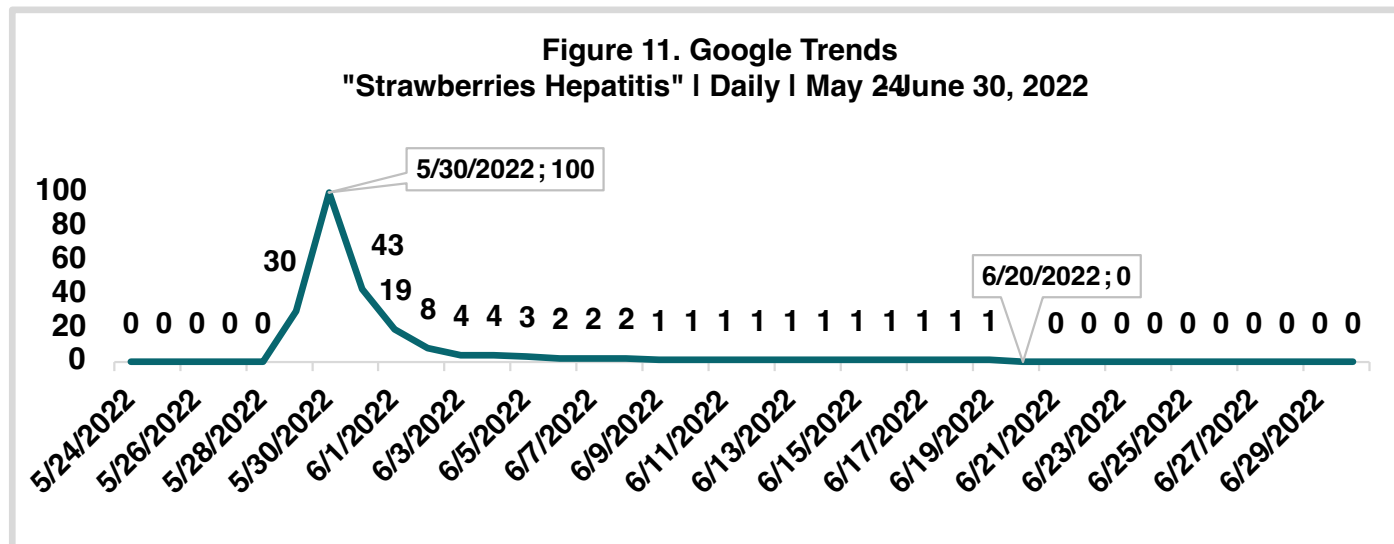


Figure 10. Google Trends
"Strawberries" | Daily | May and June 2022



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Source: Figures 9-11: Google Trends Web Search, Interest Over Time. Geography: United States. Interest Over Time measures search interest over a specific period of a specific topic, on a relative scale within 0 to 100. 100 signifies the peak interest for the time period of the chart. A value of 50 indicates half the popularity of the peak, and 0 suggests insufficient data. These charts do not compare searches of strawberries to searches of other topics.

Lastly, pricing declines align with anecdotes from an organic strawberry grower who, during an interview, recalled that prices were down for six weeks following the announcement. The grower reiterated that the timing was especially costly to California strawberry farmers, as the impacted weeks fell while the state's two largest strawberry regions, Santa Maria and Watsonville, were at peak production.

These impacts of revenue loss capture FOB price effects only and represent the lower bound on total industry costs. Retail margin losses, additional marketing costs, long-term regulatory and reputation effects are not included in these estimates.

An equivalent analysis to estimate the impact of the 2023 frozen strawberry outbreak using the same methodology was confounded by severe flooding damage to California strawberry fields in early 2023, which created supply-side impacts that could not be separated from any demand response in the shipping point data. While the impact of the 2023 outbreak cannot be estimated directly, California growers were likely less affected than they were by the 2022 announcement: the 2023 recall fell outside of months when California has primary market share, and most domestic production goes to the fresh market rather than the frozen products that were pulled from shelves.

Google Trends data also suggests that the 2023 outbreak announcement had less salience to consumers than the 2022 announcement. When measuring search interest for the term "strawberries" over the year from May 2022 to May 2023, interest peaked with a score of 100 the week of the 2022 outbreak announcement (May 29 – June 4, 2022).

By comparison, the week of the 2023 recall announcements (March 19 – 25, 2023) was only at a 42, indicating search interest was 58% lower. While recall-related search terms accounted for 9 of the top 10 search terms in the week following the 2022 outbreak, they were only half of the top 10 searches between March 15 – March 21, 2023. Lastly, while it was not until week six (July 2-8, 2022) that any recall-related search term fell out of the top 50 in strawberries-related search terms, in 2023, outbreak-related searches were no longer top 50 by week 4 (April 5-11, 2023).

Comparing [price postings](#) from the Processing Strawberry Advisory Board of California³¹ from mid-May 2022 and May 15, 2023 (the first date prices were posted in 2023), does indicate that prices received by growers for processed strawberries were lower than the previous year. Grade 1, California-sourced strawberries fell from mostly \$0.63 - \$0.65/lb, to mostly \$0.50 - \$0.56/lb., a decline of 14-23%. Meanwhile, Grade 1 strawberries sourced from Baja fell further, roughly 20%-28% to \$0.45 - \$0.46/lb. While this may have been related to the 2023 outbreak announced in March, it is difficult to parse impacts from the outbreak and other extenuating circumstances.

Frozen Berry Processors

Enteric Virus Testing and Costs

Enteric viruses, including Hepatitis A virus, are much more difficult to cultivate and detect in laboratory settings, which makes testing as a means of assuring food safety more difficult compared to bacterial foodborne pathogens, such as Salmonella. An international expert panel initially convened in 2020 to analyze the detection of foodborne viruses in berries, found two prominent flaws in end-product testing with regards to ensuring food safety.³² First, in the modeling of contamination scenarios, product testing rarely caught enteric virus infections from isolated origin events, such as an infected harvester with improper hygiene or a vomiting incident during processing. Additionally, the study states that “it is not possible to accurately determine the significance of a positive test result with respect to human health risk, although it should merit scrutiny within the supply chain.”³³ While the panel calls on testing as a potential tool in a holistic approach to foodborne illness management, it also states, “routine end-product virus testing is not likely to do much in the way of preventing potentially contaminated product from reaching the market.”³⁴

The panel found that nearly all virus testing of berries conducted in commercial labs is done to meet Certificates of Analysis requirements for downstream supply chain customers. Additionally, the published report states that a “cascade of product testing upstream of the frozen berry supply chain” commenced following the 2023 HAV outbreak. This finding was confirmed in interviews conducted for this report of food safety experts currently and formerly employed by frozen berry processors. They stated that while testing efforts are focused on imported berries, testing on frozen berries is typically included as a requirement in contracts with retailers.

³² Jaykus, Lee-Ann, et al. “Detection of foodborne viruses in berries—State of science and future considerations.” *Food Control* 180 (2026): 111436. <https://doi.org/10.1016/j.foodcont.2025.111436>

³³ Ibid., 30.

³⁴ Ibid., 31.

³⁵ Ibid., 15.

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Testing is required at the batch or lot level, which makes it difficult to estimate total cost to industry, since the volume of each batch can vary widely both between and within factories. According to interviews with frozen berry processors, a “batch” typically consists of a singular run-time or shift. As such, testing is conducted after the berries are already frozen. Thus, concerns over food waste stemming from delays in testing are limited, and costs are typically limited to storage time in freezer facilities.

According to one interview, tests typically cost around \$150-\$200 per test. If additional confirmatory tests are needed, costs typically rise to exceed \$1,000 with turnaround taking several weeks. In the expert panel study, a case study is included from a “very progressive berry processor” who changed and intensified their berry testing protocols between 2021 and 2023.³⁶ In 2023, the year with the highest ratios of test to product, this processor conducted 1,598 composite samples and tests for approximately 9 million kilograms of product to the tune of “hundreds of thousands of dollars.” If on average tests cost between \$150 to \$200 each, the company likely spent between \$240,000 to \$320,000 on testing over the course of the year, which is equivalent of \$0.012 - \$0.016 per pound or \$26.63 - \$35.51 per metric ton (Table 4). In 2021, when the company was using a more standard industry approach to testing, they conducted an almost identical 1,570 tests, but processed 14 million kilograms of product, which was about 50% higher than their 2023 processing volume. Under the less intense approach, the company likely spent between \$236,000 to \$314,000 total; \$0.008 to \$0.01 per pound; and \$16.82 to \$22.43 per metric ton.

Table 4. Imputing Total Cost Estimates from Case Study of Enteric Virus Testing Regime

	Baseline Sampling Program (Year 1, 2021)	Intensified Sampling Program (Year 3, 2023)
Representative volume of product	Approx. 14,000 MT	Approx. 9,000 MT
Number of composite samples and RT-qPCR tests for HepA/Human Norovirus	1,570	1,598
Approximate Lb. per Test	19,700	12,400
Total Cost Estimate	\$235,500 - \$314,000	\$239,700 - \$319,600
Cost per Lb. of Product	\$0.008 - \$0.01	\$0.012 - \$0.016
Cost per MT of Product	\$16.82 - \$22.43	\$26.63 - \$35.51

Source: Volumes and annual testing totals come from Table 6 – Comparative summary of testing results obtained from laboratory of industry stakeholder (IQF processor/packer) using random sample-grab (baseline) vs. square root-based (intensified) sampling approaches from “Detection of foodborne viruses in berries – State of science and future considerations.”

Cost estimates are imputed from volume and annual testing totals with a range of \$150 - \$200 per test, based on industry interviews with California frozen berry processors.

³⁶ Ibid., 17-18.

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We can roughly extrapolate the total cost of enteric virus testing (HAV and human norovirus) using testing frequency from the case study, costs per test from industry interviews, and frozen volumes from the Processing Strawberry Advisory Board; as demonstrated in Table 5 below. If we assume that the baseline sampling level was status quo pre-outbreak, and that the intensified sampling level was the status quo post-outbreak, it represents an increase of \$1.5 million - \$2.0 million in additional testing annually.

Table 5. Extrapolating Total Cost to California Frozen Berry Processors of Testing

	Baseline Sampling Level	Intensified Sampling Level
California Processor's Average Annual Volume ('21 – '25)	332.7 million pounds	332.7 million pounds
Est. Number of Tests	16,900	26,800
Cost for Testing	\$2.5 - \$3.4 million	\$4.0 – \$5.4 million

Note: This analysis assumes that tests per volume is approximately consistent with levels of the case study detailed in Table 4, immediately above. California Processor's Average Annual Volume is sourced from page 8 of the Processing Strawberry Advisory Board of California's 2025 Annual Report. The volume is representative of frozen outputs and includes all strawberries frozen in California, including fresh strawberries brought in from Baja California, Mexico. Between 2021 and 2025, 22% of all fresh berries marketed for processing in California (including for juicing) were imported from Baja California, Mexico.

Implementing Additional Food Safety Measures

In addition to increasing testing levels following the 2022 outbreak, frozen berry processors implemented reforms to better assess risk levels of their upstream suppliers, which are typically both foreign and domestic growers. One processor shared that since the outbreaks, they have begun requesting additional assurances for good agricultural practices (GAPs) and conducting specific enteric virus hazard analysis down to the individual farm level. The processor stated that it will decline to do business with suppliers unless it knows the farm-level food safety conditions. To conduct more audits and targeted record compliance, the processor and its affiliate companies have had to hire additional full-time staff both in the U.S. and abroad.

Using input from subject matter experts and food safety professionals, the American Frozen Food Institute (AFFI) also developed [EViews](#), an early warning risk management system to address enteric virus risk in the global berry supply chain.

²⁷ Ibid., 6.

²⁸ Interviews were limited in quantity. In total, interviews were conducted with two organic strawberry growers, two current or former frozen berry processor food safety officers, and one strawberry industry representative.

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On January 17, 2025, the FDA [announced](#) a strategy to prevent human norovirus and hepatitis A outbreaks associated with fresh and frozen berries. The new prevention strategy establishes goals, research strategies, and actions for the FDA, industry, and other interest holders related to the prevention of enteric viruses in the global berry industry. A [publicly available summary document](#) outlines the strategy focus on promoting high rates of FDA food safety requirement compliance, encouragement of the berry industry to ensure consistent application of processes related to pre- and post-harvest sanitary practices for domestic and global berry operations, broadening scientific knowledge about the presence of viruses in fresh and frozen berries, and incentivizing both industry and government to embrace immunization programs for worker health. Since the strategy was released on the last business day before a presidential administration change, it is unclear how the FDA will move forward with implementation, and thus the total amount of associated costs cannot yet be determined. However, interviews indicate that strategy's goals have been taken up by downstream supply chain partners, an example of how private standards and compliance often exceed enforced government regulations.

Improvements regarding food safety protocols have continued to evolve, and it is difficult to calculate the full cost of additional measures being taken by the industry in direct response to the 2022 and 2023 HAV outbreaks. However, based off conducted interviews and analysis, the largest changes that have come from the 2022 and 2023 HAV outbreaks have been seen with frozen berry processors, who have placed an increased emphasis on food safety protocols for imported products. Furthermore, at this time it appears that minimal changes are being requested of U.S.-based growers at the farm level, since they were generally already compliant with hygiene and food-handling best practices even before the 2022 and 2023 HAV outbreaks.

Survey Results: Reputational Effects for California Strawberries

The California Strawberry Commission conducted consumer surveys in 2023 and 2025 which included attitudes towards and usage of strawberries, and the industry's reputation. While the 2023 survey was nationwide, the 2025 survey was limited to California residents.

The 2023 survey was conducted in May 2023, only a few weeks after the recall of frozen strawberries and during the second outbreak. Its results found an overall positive reputation of the California strawberry industry, which further improved in the 2025 survey. In the 2023 survey, CSC found that about 8% of consumers noted concerns about the safety of strawberries as a reason they may not purchase. However, food safety concerns were the lowest ranked of all potential attributes surveyed, such as, but not limited to: strawberries don't look good on store shelves, they are too expensive, they go bad before eating, etc.

Between the 2023 and 2025 surveys, there was a statistically significant increase in the number of California residents reporting purchase of organic strawberries and an increase in the number of "heavy" strawberry purchasers - people purchasing strawberries either weekly or several times a week.

While the exact question regarding concerns over food safety as a reason to not purchase was not included in the 2025 survey, the importance of "ensuring food safety" did not change between the 2023 and 2025 surveys for California residents. Additionally, the number of Californians who were highly satisfied with the California strawberry industry as "ensuring food safety" (i.e., ranking it as either an 8, 9, or 10 on a 10-point scale) increased from 62% in 2023 to 71% in 2025.

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Unfortunately, the surveys were not designed to specifically capture the reputational impact of the HAV outbreaks on the strawberry industry. However, they do indicate that the number of people avoiding strawberries due to food safety concerns was relatively modest (8%) during an active outbreak and recall. Additionally, changes between the 2023 and 2025 survey, including increases in organic purchases, increases in heavy strawberry purchasers, and improvement in satisfaction with the California strawberry industry's performance in "ensuring food safety" all point towards improvement in the strawberry industry's reputation since the outbreaks. Thus, any harm that may have been visible in the immediate aftermath of the recalls in 2022 and 2023 has potentially been recovered. This is backed up by the total quantity of strawberries sold and produced in subsequent years, which have both continued to increase, even though price fluctuations have resulted in tough financial years for growers.

CONCLUSION

This report set out to study the economic costs on the domestic strawberry industry caused by the 2022 and 2023 Hepatitis A outbreaks from imported organic strawberries.

FDA's initial communications did not provide clear information regarding the origin of the implicated strawberries. This lack of clarity likely contributed to demand destruction for California strawberries in the aftermath of the 2022 announcement. Based on Google Trends data, consumer salience around the outbreak peaked on May 30th, before updates indicated imported produce as the source of the outbreak on May 31st and further clarification that impacted strawberries were from Baja California, Mexico on June 1st. By June 1st, Google searches for "strawberries" had declined by 63% from its May 30th high.

For U.S. strawberry growers, the largest impacts stem from a demand shock resulting in decreased prices following the May 28, 2022, announcement of the outbreak. In the five weeks following the announcement, prices for California's organic and conventional strawberries fell by approximately 27% and 29% respectively, resulting in baseline estimated losses for California growers of \$125 million or approximately 4.6% of total 2022 wholesale revenues. Based on interviews with industry members, California growers do not appear to have incurred additional food safety costs following the 2022 and 2023 outbreaks, as industry-leading food safety protocols were already in place prior to those events. After the short-term economic disruption, the long-term economic impact on California strawberry growers has been minimal.

California growers have not had to adjust their normal operations; however, frozen berry processors have explored increased testing regimes, both on their own initiative and in response to retailer pressure. While frozen berry processors have indicated that they generally want to focus testing on imported produce, which comes with a higher risk of enteric virus exposure, certain retailers have started to require testing on all frozen products, regardless of whether they are sourced domestically or internationally. The benefits of testing frozen products remain unclear. Increased testing requirements driven by retailer contracts, processor preferences, and evolving government expectations would increase costs and could further reduce California strawberry growers' already tight margins.

Even though an enteric virus outbreak in berries has not been traced to U.S. berry growers in more than 35 years, California strawberry growers bore the brunt of the 2022 outbreak-related revenue declines. Foodborne pathogens do not know borders, and outbreaks can cause category-wide consumer backlash.



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Strawberries have a global supply chain. In today's global food supply chain, preventing foodborne illness is a shared responsibility among growers, shippers, processors, importers, retailers, and regulators worldwide.

Corrective actions and preventive measures must be guided by science and directed towards the source of the issue to avoid unintended consequences, including actions that disproportionately affect one segment of the supply chain without improving public health outcomes. Transparency, accountability, and collective learning remain critical to advancing food safety.