Economic Impacts of Highly Pathogenic Avian Influenza (H5N1) on Dairy Farms and Milk Supply

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Abstract

This paper assesses of economic impacts of the H5N1 outbreak in dairy cows in California. We develop a simulation model that incorporates preliminary assessments of the prevalence of infected cows in herds with H5N1, the progression of the disease through a herd, and dairy farm management of the disease. We assess impacts on aggregate California dairy production and market implications. We also estimate impacts of H5N1 on milk shipments using a large sample of herds infected at different dates as the disease spread through the region. Finally, we use USDA data on monthly milk production in California and simulated quantities assuming no H5N1 to calculate shortfalls in milk quantities and revenue.

1. Introduction and Background

In March 2024, the first cases of HPAI A(H5N1) (hereafter, "H5N1") in dairy cows were identified in Texas and Kansas and subsequently confirmed in 14 additional states. On August 30, 2024, the first case of H5N1 in dairy cattle was found in California, which has been the first major dairy-producing region to document widespread H5N1 among dairy herds. By the end of 2024, about 70% of all commercial dairy herds in California had been infected with H5N1. As of June 10, 2025, 767 herds (75% to 80%) have contracted H5N1 with impacts centered in the San Joaquin Valley, where herds are larger and milk production per cow is higher. We estimate that herds that typically produce more than 90% of California's milk experienced losses from H5N1. Although most cows continue to produce marketable milk after infection and not all cows in the herd with H5N1 are affected, the outbreak is impacting milk production, operating costs, and the economics of the dairy industry.

Several dairy and veterinary science publications characterize the spread and effect of H5N1 in dairy herds (Baker et al., 2025; Morel et al., 2025; Rodriguez et al., 2025). Our paper characterizes the impacts of H5N1 on the time path of milk production, the supply of milk over time, costs and revenues of dairy farms, and market prices using methods that can be generalized to future outbreaks in states not yet affected by H5N1. Our research uses a unique sample of California dairy farms to parameterize a model of the dynamic effects of the disease as it reduces production of individual cows, spreads through cows in affected herds, and spreads through the population of herds. As far as we know, this is the first paper to characterize H5N1 in a population of dairy herds and draw industry implications for economic aggregates.

2. Methods

We use several methods to characterize the spread of H5N1 within and among dairy herds in California, and to evaluate the costs of H5N1 on the dairy industry. First, we develop a simulation model that incorporates preliminary assessments of the prevalence of infected cows in herds with H5N1, the progression of the disease through a herd, and management of infected cows. We aggregate to California dairy production and economic effects based on the current understanding of the share of aggregate production in herds likely to be affected. The model is flexible and allows easy adjustment of key parameters as more information about H5N1 in dairy cows becomes available.

In addition, we conduct statistical analysis of the impact of H5N1 on milk shipments using confidential data. We use data on daily milk shipments for a sample of 493 San Joaquin Valley dairy herds from August 1, 2024, through December 1, 2024 (for about 20% of the sample, data is restricted to September 1 through November 30). The sample contains information on production for a total of about 45,000 herd-days and allows us to evaluate the changes in daily shipments by day of H5N1-positive status.

Finally, we include a forecasting model based on the time series of monthly milk production in California and calculate the loss of revenue from milk production to date.

3. Simulation Model of the Effect of H5N1 on Marketable Milk Production in California

3.1 Modelling the Effect of H5N1 on Milk Production

We calculate the expected losses in production for a typical cow for a single lactation cycle and extend our calculations to characterize the potential loss of milk production in a typical dairy herd, and the state. This framework does not incorporate several potentially significant features including differential rates of disease across a lactation cycle and differential rates of disease across first, second, or later lactations. The model can readily incorporate such features when data become available.

The calculations do not yet incorporate issues related to farm management for profitability. Thus far, impacts from the price of milk, the cost of replacement heifers, the value of potential replacement heifers in the beef market, and the value of cull cows in the beef market do not seem to be the major driving features in responses to H5N1.

We define annual production for a dairy cow i to be the sum of milk per day over the total lactation cycle:

$$Y_i = \sum_{t=1}^{T} y_{it} \tag{3.1}$$

where y_{it} is the output of cow i on day t of a T-day lactation cycle, typically about 305 days per year. Milk production per cow per day varies systematically across days in the cycle starting low for a few weeks, growing to a peak after a few months, and then declining over the remaining months of the lactation cycle. Annual average milk production per cow differs by 20% or more across cows indexed i in Equation 3.1. Cows are culled during and after lactation cycles when they are injured, develop infertility or other health issues, are less productive than expected, or otherwise are no longer expected to be profitable relative to the alternatives. The number of lactations per cow typically ranges from one to three or four with an average of about 2.5, and depends on the price of milk, the price of feed, and other economic drivers. The equations for milk production per cow per day might be written to incorporate a random cow-specific production shock to reflect that milk production and the health of cows are generally not known with certainty.

The loss of annual production from H5N1 per cow is equal to the days of lactation affected due to infection, multiplied by the average production expected during the days affected. We denote the day the infection begins as I. The infected cow begins to experience loss in milk production immediately after infection but does not show other symptoms of H5N1 for AS days, after which it may show clinical symptoms of flu with probability γ. If a cow never develops visible symptoms of flu, she stays with the main herd until she recovers, during which time she produces less milk but her milk is not discarded like it would be during the hospital stay. If a cow becomes symptomatic, she is placed in the hospital pen on day $NS + 1$. After S days in the hospital pen, the cow either recovers and is placed back with the herd on the day $S + 1$or dies with probability δ. If the cow recovers and is placed back with the herd, the cow continues to recover to full production until the day R after which there are no more losses from H5N1. We assume that cows that become infected but do not become symptomatic do not die from H5N1.

Using the notation just defined, the equation for the expected marketed milk of a cow identified as infected with H5N1 is as shown in Equation 3.2:

$$Y_i = \sum_{t=1}^{N} y_{it} - \sum_{t=I}^{AS} Loss\%_t * y_{it}$$
$$-\gamma\left(\sum_{t=AS+1}^{S} Loss\%_t * y_{it} - (1-\delta)\sum_{t=S+1}^{R} Loss\%_t * y_{it} - (\delta)\sum_{t=S+1}^{N} y_{it}\right)$$
$$-(1-\gamma)\left(\sum_{t=AS+1}^{R} Loss\%_t * y_{it}\right) \quad (3.2)$$

In Equation 3.2, $Loss\%_t$ is the quantity of milk per day that is expected to be lost from an infected cow based on the day the cow was infected with H5N1, expressed as a percentage of annual milk marketed. We discuss the intuition and economic logic of Equation 3.2 below:

- I is the number of the first day of infection in the lactation cycle, for example, a cow may become infected on day *t* = 200 of her *N* = 305-day lactation cycle.

- AS is the number of days until the cow becomes symptomatic. It is our understanding that recent evidence suggests that this period is about two weeks in herds that are being closely observed for the disease. We understand that AS may vary across cows within a herd and in some herds the symptoms of H5N1 may never be identified.
- γ is the probability of a cow becoming symptomatic. Some cows will not show clinical signs of H5N1 and so will not be separated from the main herd.
- S is the number of days the cow is separated from the main milking herd in the in the hospital pen after becoming symptomatic. It is our understanding that these cows continue to produce milk but during this period, milk is not marketed.
- R is the number of days the cow takes to recover full milk production once placed back into the herd.
- δ is the mortality rate. If a cow recovers, it is placed back into the herd and resumes full expected production after day R; if a cow dies or is culled, it loses all production after it dies. We assume that the cow either dies or is placed back with the herd on the day $S + 1$.

To summarize, y_{it} represent the amount of milk produced for a given cow, i, which is expected to vary across the lactation cycle for each cow. The number of days in each segment of disease progression, represented by AS and S, may differ by cow.

In the next section, we apply the calculations above to a simulation model of milk production for a typical dairy cow.

3.2. Simulation of the Effect of H5N1 on Marketable Milk from a Typical Dairy Cow

We model the effect of H5N1 on milk production of a typical dairy cow as a 16-week cycle, where H5N1 begins to affect milk production in Week 1, and by Week 16, the cow is recovered and back to full expected milk production. Depending on the timing of H5N1 relative to the lactation cycle of an individual cow, the cow may not return to full pre-H5N1 production if H5N1 affected the later stage of the milk cycle when production is decreasing over time already. The cow may recover from H5N1 and stop shedding the virus in a few weeks after the infection, but based on our current knowledge, it may take several months for the cow to return to full expected milk production.

We consider two scenarios for cows infected with H5N1. In one scenario, the infected cow is identified and treated in the hospital pen. While the cow is in the hospital pen, her milk is discarded. Alternatively, if the infected cow is not identified and treated, it remains with the herd. In our current simulation model, we assume that cows experience the same drop in milk production under both scenarios. However, it is possible that cows that end up being treated had experienced worse symptoms of H5N1. Table 1 describes the loss in marketable milk from a typical dairy cow during the 16 weeks of H5N1.

<u>Weeks 1 and 2: Infection to Symptoms</u>

Current reports from veterinarians and dairy operators indicate that cows may not show symptoms of H5N1 other than the drop in milk production for up to two weeks after infection, which makes it impossible to remove infected cows from the herd during that period. Milk production begins to drop immediately after infection and milk collected during this stage enters the milk supply. We assume milk production falls by about 25–30% before a cow may be treated.

Weeks 3 and 4: Treatment of Infected Cows

If a cow with H5N1 is identified, it is removed from the herd and placed into a hospital pen. During that time, the milk produced by the symptomatic cows is either dumped or fed to the calves. Therefore, the entire output of the cow does not enter the milk supply during that period. Current reports indicate that on average, the cows stay in the hospital pen for 2–5 days, but some cows may be kept longer. Cows that are infected with H5N1 but are not identified stay with the herd until they recover. In our model a cow with H5N1 is either treated in Week 3 or stays with the herd.

Weeks 5–16: Recovery of Milk Production

Current reports suggest that cows may take several months to return to full milk production once recovered from H5N1. We model milk recovery through Week 16 after initial infection. This period can be adjusted as better data becomes available.

Table 3.1: The Effect of H5N1 on Milk Production for a Typical Dairy Cow, by Week of Infection

Week of H5N1	Description of H5N1 Progression	Marketable Milk	
		Treated Cows	**Not Treated Cows**
		% of Expected	
1	Initial Infection	75	75
2	Initial Infection	70	75
3	Infected Cows are Treated or Left with the Herd	28	65
4	Treated Cows Return to Herd	65	70
5	Recovery, Milk Production Still Affected	70	70
6	Recovery, Milk Production Still Affected	75	75
7	Recovery, Milk Production Still Affected	77	77
8	Recovery, Milk Production Still Affected	80	80
9	Recovery, Milk Production Still Affected	81	81
10	Recovery, Milk Production Still Affected	82	82
11	Recovery, Milk Production Still Affected	83	83
12	Recovery, Milk Production Still Affected	85	85
13	Recovery, Milk Production Still Affected	90	90
14	Recovery, Milk Production Still Affected	95	95
15	Recovery, Milk Production Still Affected	97	97
16	Milk Production Returns to Normal	100	100
Marketable Milk, % of Expected Total for 16 Weeks of H5N1		**78**	**81**

Note: This table does not incorporate the probability of death from H5N1. We assume that Treated cows and Not Treated Cows have the same loss in production by week of H5N1 except Weeks 2 through 4. Treated cows are in the hospital pen for four days.

According to Table 3.1, a typical cow is expected to lose 19% - 22% of its production during the 16-week period of H5N1 infection and subsequent recovery.

A typical dairy cow in California is retained for an average of two or three lactation cycles. Each lactation cycle is 305 days long, and the milk output of each cow varies over the cycle. We follow the conventional definition of stages of lactation: early lactation, 1 to

100 days after parturition; mid-lactation, 100 to 200 days after parturition; and late lactation, 200 to 305 days.

During the early lactation, milk production begins at a high rate and continues to increase until about six weeks after calving. After milk production peaks, milk output remains high, although declining, through mid-lactation, and continues declining in the late lactation stage. The average lactation curves vary by breed and age of cow.

In our model, we assume a cow with an average output of 25,000 pounds of milk per year. With a 305-day lactation cycle, an average cow produces 82 pounds of milk per day. We assume that during periods of low production, such as in the late lactation stage, the output of the cow is about 43 pounds of milk per day. During periods of high production, we assume the output to be 95 pounds milk per day. Table 3.2 describes the average loss of production for cows with H5N1 based on their treatment status and the period of lactation during which they got the flu.

Table 3.2: Loss of Production for an Average Cow Infected with H5N1

	Yield (pounds/day)	Loss % of Expected	
		Treated	Not Treated
Low production period	43	4.2	3.6
Average production period	82	8.0	6.9
High production period	95	9.2	8.0

For cows that are treated in hospital pens, calculations using assumptions stated above suggest that on average production loss from a cow infected by H5N1 is about 8%. If the cow is infected during the early high-production stage of the lactation cycle, the loss could be as high as 9%. If the cow is infected during the low production stage of the lactation cycle, the loss can be as low as 4%.

For cows that become infected but are not treated and remain with the main herd on average production loss from H5N1 is 7%. The loss can range from a high of 8% if the cow was infected during the high production stage of the lactation cycle, to a low of 3.6% if the cow was infected during the low production stage of the lactation cycle.

In the next section, we model the effect of H5N1 on a dairy herd, where H5N1 spreads over time and, at any given time, there are cows at various stages of H5N1 infection.

3.3. The Effect of H5N1 on a Dairy Herd

According to reports communicated to us from veterinarians in the field, the number of cows exhibiting clinical symptoms of H5N1 and the number of cows being pulled from the main herd vary by herd. Table 3.3 shows the parameters we use to estimate the effect of H5N1 on a typical dairy herd. In this scenario, 40% of the herd is never infected with H5N1. Of the 60% that gets infected, two-thirds receive treatment and one-third does not.

Table 3.3: Share of Cows Infected, Treated, and Not Treated, in a Typical Herd

	Total Herd	Infected Cows
Share Treated	0.4	0.67
Share Infected but Not Treated	0.2	0.33
Share Never Infected	0.4	

It also appears that H5N1 spreads through a herd in about 30-45 days. It seems to take about another month after that for the final infected cows to stop shedding H5N1 and for the herd to be on the path to be declared H5N1-free. However, milk production does not recover fully for another few months.

We model the spread of H5N1 through a cow herd over five weeks using a logistic distribution. Percentages of exposed cows per week are obtained using Equation 3.3:

$$N(t) = \frac{N_{\mathrm{T}}}{1 + \exp\left(r * \left(\frac{T}{2} - t\right)\right)} \tag{3.3}$$

In Equation 3.3, $N(t)$ is the percentage of cows in a herd exposed to H5N1 in week t, N_{T} is maximum percentage of the herd exposed, T is the time period by which the last cow becomes exposed; and r is the exposure growth rate. In our calculations we assume that all cows in a herd are exposed to H5N1 by Week 5. Table 3.4 shows the percentage of cows exposed and infected each week, reaching the maximum number of infections in Week 5. The percentage of infected cows is based on the share of infected cows from Table 3.3.

Table 3.4: Progression of H5N1 Through a Typical Herd

Week of H5N1	% Cows Exposed	% Cows Infected
1	14.6	8.8
2	21.1	12.7
3	28.6	17.2
4	21.1	12.7
5	14.6	8.8
Total	**100**	**60**

Table 3.5 describes the effect of H5N1 on herd production over the 21-week period from the first H5N1 infection to the time when the entire herd returns to full expected production.

Table 3.5: Progression of H5N1 and the Effect of H5N1 on Marketable Milk for a "Typical" Herd

	Week of H5N1																				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
	% of Infected Cows in Each Week of H5N1, in a Typical Herd																				
	9	13	17	13	9	0															
		9	13	17	13	9	0														
			9	13	17	13	9	0													
				9	13	17	13	9	0												
					9	13	17	13	9	0											
						9	13	17	13	9	0										
							9	13	17	13	9	0									
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														9	13	17	13	9	0		
															9	13	17	13	9	0	
																9	13	17	13	9	0
% of Herd Infected	**9**	**21**	**39**	**51**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**51**	**39**	**21**	**9**	**0**
% Loss of Marketable Milk per Week	**2.2**	**5.6**	**13.1**	**18.5**	**22.9**	**21.8**	**19.8**	**15.7**	**13.9**	**12.5**	**11.6**	**10.7**	**9.6**	**8.0**	**6.0**	**3.8**	**2.0**	**0.8**	**0.3**	**0.0**	**0.0**
% of Expected Milk Production	**97.8**	**94.4**	**86.9**	**81.5**	**77.1**	**78.2**	**80.2**	**84.3**	**86.1**	**87.5**	**88.4**	**89.3**	**90.4**	**92.0**	**94.0**	**96.2**	**98.0**	**99.2**	**99.7**	**100.0**	**100.0**

According to our model, herd production will return to 100% of expected by 20 weeks after the first cows are infected with H5N1. Losses by week can be as high as 23% in Week 5, decreasing to 0.3% in Week 19. The herd would return to 100% of expected production by Week 20. Figure 3.1 illustrates the effect of H5N1 on milk production shown in Table 3.5

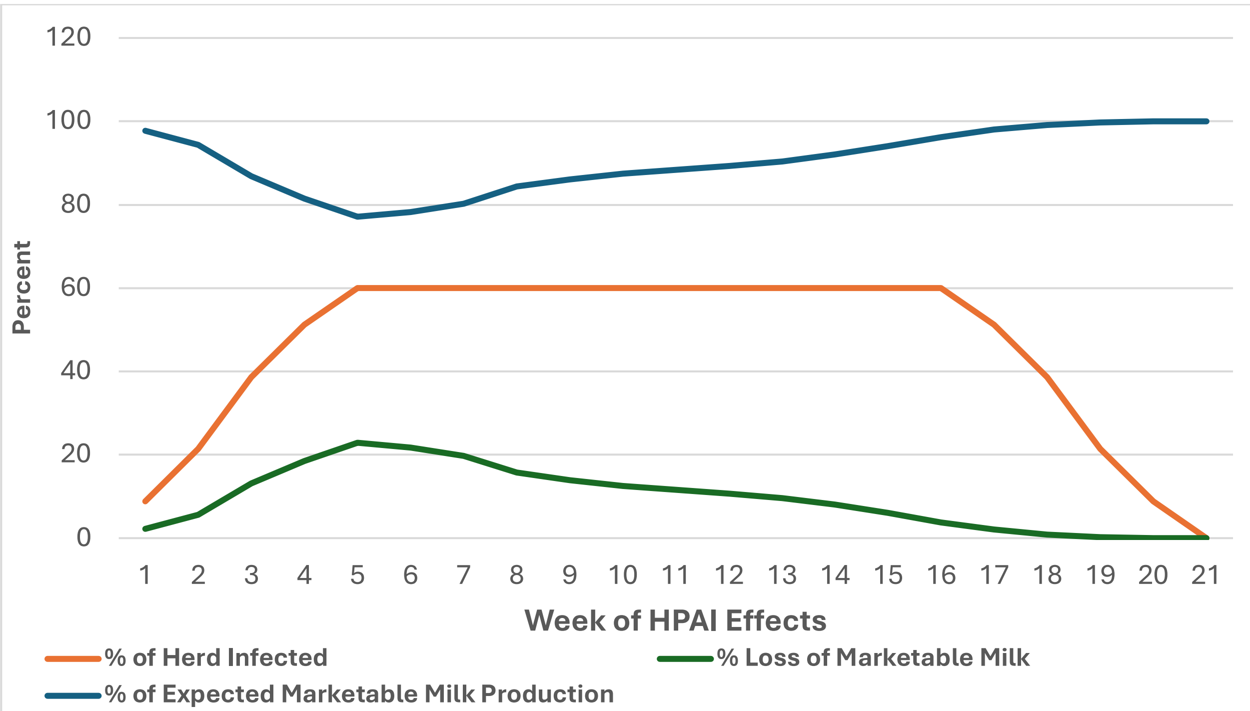

Figure 3.1: Progression of H5N1 and the Effect of H5N1 on Marketable Milk for a Typical Herd

As the share of cows infected and still affected peaks in Week 5, production drops the most in Weeks 5–7 and then returns to normal over the remaining weeks. The loss of expected production per week depends on the share of cows in various stages of H5N1. Production drops the most when the majority of affected cows are in Weeks 3 and 4 of H5N1, as those are the weeks when cows typically get treated and marketable production is the lowest (Table 3.1). The computational model included with this report allows adjustments to the rate and duration of H5N1 spread through the herd.

3.4. Statewide Effects of H5N1

The first H5N1 positive notices were issued to herds in California on August 30, 2024. As of June 10, 767 herds (75% - 80% of all California herds) have contracted H5N1, with impacts centered in the San Joaquin Valley, where herds are larger and milk production per cow is higher. We estimate that the subset of herds responsible for producing 90% of California's milk experienced losses from H5N1. Figure 3.2 describes the progression of H5N1 in California dairy herds.

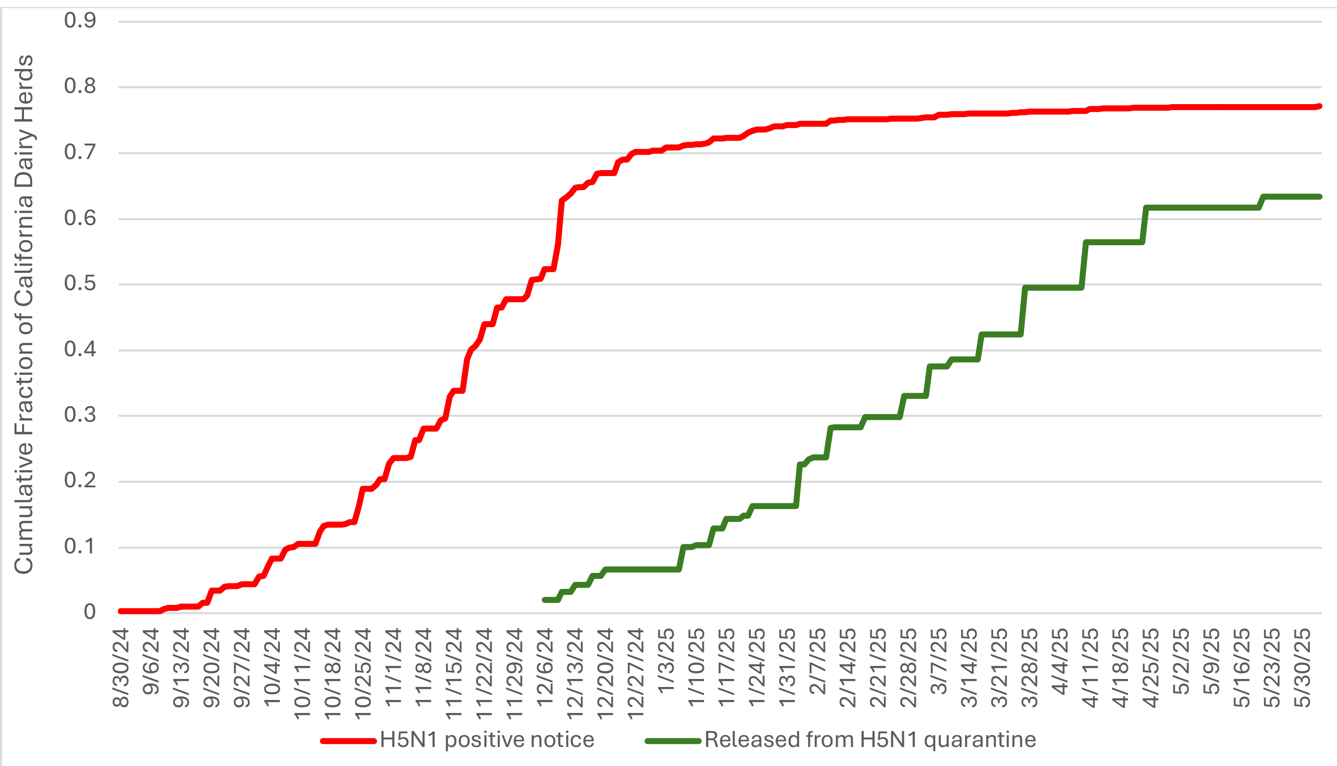

Figure 3.2 Cumulative fraction of California dairy herds that had tested positive for H5N1 by a given date and the fraction of herds that had been released from quarantine after testing negative.

Source: USDA Animal and Plant Health Inspection Service, Aphis.usda.gov/livestock–poultry–disease/avian/avian–influenza/hpai–detections/hpai–confirmed–cases–livestock;

We assume there is a lag between the time the herd became affected with H5N1 and the positive notice date. In our simulations we assume the lag is two weeks. Hence, herds that received their positive notice in the fourth week of August were already affected by H5N1 starting in the second week of August, and so on.

We combine the information on the share of herds affected by H5N1 from Figure 3.2 with the simulation of H5N1 progression from Table 3.5 and calculate the expected loss of marketable milk in California by calendar month. Table 3.6 shows the results.

Table 3.6: Estimated Statewide Losses in Marketable Milk by Month

	Percentage Expected Loss	Avg. Share of Annual Production
August	0.03	0.082
September	0.87	0.079
October	3.78	0.082
November	7.90	0.080
December	11.36	0.084
Total Aug-Dec %	**4.85**	**0.406**
January	8.88	0.086
February	4.30	0.080
March	1.11	0.089
April	0.42	0.086
May	0.23	0.088
June	0.10	0.082
July	0.03	0.083
Total Jan-July %	**2.14**	**0.594**
Total Aug-July (12 months)	**3.24**	**1.000**

According to our calculations and given the model framework, assumptions, and input data, the 12-month losses of marketable milk from H5N1, beginning in August 2024 and ending in July 2025, are projected to be about 3.2%. These projections are based on the parameters selected to describe the effect and spread of H5N1 through a typical herd, and also the assumption that the 77% of the herds affected by H5N1 as of mid-June 2025 are larger herds in the Central valley and are producing around 90% of marketable milk in California.

4. California Farm Milk Shipments Related to Dates of H5N1 Notification

This section reports on a preliminary assessment of data on the H5N1 notification date and daily milk shipments for a sample of 493 San Joaquin Valley dairy herds from August 1, 2024, through December 1, 2024 (for about 20% of the sample, data is restricted to September 1 through November 30). The sample contains information on production for a total of about 45,000 herd-days.

For each herd, we compared the average daily production before the H5N1 confirmation to daily production after the H5N1 notification. We calculated differences in a 7-day moving average production per day for each herd from the average in the period before that herd was notified as having a confirmed test for H5N1 as follows:

$$dY_{id} = \left(\frac{Y_{id} - \bar{Y}_{i(pre-H5N1}}{\bar{Y}_{i(pre-H5N1}} \right). \tag{4.1}$$

In Equation 4.1, Y_{id} is the seven-day moving average of the daily production of the herd i before and including the day d. The difference dY_{id} is the proportional difference between the 7-day moving average of the daily production of the herd i on the day d and the average daily production in the period before this herd got its H5N1 notice. Average daily production of the herd i before the H5N1 notice for the herd i is calculated as follows:

$$\bar{Y}_{i(pre-H5N1} = \frac{\sum_{d=1}^{N_i} (Y_{id})}{N_i}. \tag{4.2}$$

In Equation 4.2, N_i is the number of days in the dataset for herd i before the H5N1 notice. This number varies across herds. Those herds that were infected with H5N1 relatively early had fewer days of the pre-H5N1 days in the sample.

We represent the relationship between the date of the notification of the positive test for H5N1 and daily milk shipments as follows:

$$dY_{id} = \beta_0 + \beta_1 D_{id} + \beta_m M_d + \varepsilon_{id} \tag{4.3}$$

In Equation 4.3,

- dY_{id} is the change from average daily production for herd i on day d calculated using Equation 4.1
- β_0 is the intercept
- D_{id} is the number of days d relative to the H5N1-positive notice date for the herd i, with β_1 is the coefficient of on this date.
- M_d is a set of dummy variables one for each month, with β_m taking values for each month September through December.
- ε_{id} is the error term

We estimate this model as a linear regression for observations for days from September 1 through December 31. Figure 4.1 contains a plot of the average predicted value of the regression for each day relative to the date of the positive H5N1 notification for that farm. The percentage differences plotted in Figure 4.1 start 40 days before the day of positive H5N1 notification and continue through 80 days after the day of positive H5N1 notification day. Along with the predicted differences across herds, Figure 4.1 displays the 95% confidence bands for each estimate.

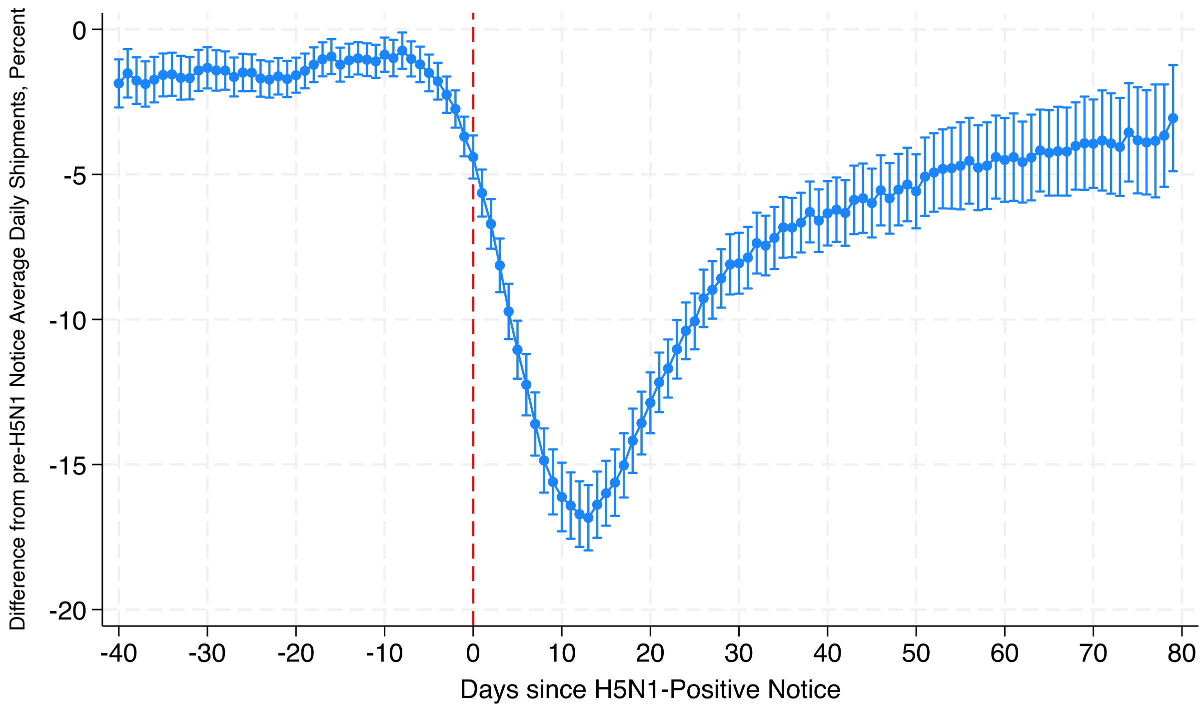

Figure 4.1: Average difference in daily milk shipments relative to the H5N1 Notification date

Note: The figure displays the predicted changes in the 7-day moving average of daily milk shipments relative to pre-H5N1 notice average, estimated using a linear regression with month dummy variables and clustered standard errors. Figure 4.1 includes 95% confidence intervals.

Figure 4.1 shows that, on average, herds experienced a drop in milk shipments starting several days before their notification of confirmation of H5N1. This is expected when there is a lag between the time H5N1 begins to affect milk shipments in a herd and the date H5N1 is confirmed in the herd. Daily milk shipments for the herd continued dropping for about two weeks following the notification, with a drop of about 16% relative to the high in relative shipments, which tends to occur approximately one week before notification. From the minimum, relative milk shipments grow gradually over the over the next two months.

Figure 4.1 shows differences in milk shipments relative to before the day of the H5N1 notification for each herd. It does not show production relative to the expected milk shipments that would have been expected for that herd on a given calendar date without infection with H5N1. Figure 4.1 is consistent with evidence of aggregate milk shipments and with reports of the impact of H5N1 on individual cows and the rate at which H5N1 has spread through herds. Figure 4.1 is also consistent with data reported in Peña-Mosca et al., 2025.

5. Effects of H5N1 on California Milk Revenue and Economic Prospects for the Dairy Industry

As of June 2025, H5N1 has effectively stopped spreading through dairy herds in California, with only one new infection reported since the beginning of May 2025. However, some of the previously infected herds are still recovering and state milk production is still affected. We use simple state-specific trends and seasonality to compare actual milk production in October 2025 through April 2025 to projections for each month. Table 5.1 shows actual production by month compared to the forecast based on monthly milk production since 2015.

Table 5.1: Estimated Losses in Marketable Milk Production in California by Month

Month	Actual Production	Production Forecast Based on pre-H5N1 Production	Estimated Loss of Production due to H5N1	
	Million lbs		*Million lbs*	*%*
Aug 2024	3,380.00	3,380.00	0.00	0.00
Sep 2024	3,211.00	3,247.14	36.14	1.11
Oct 2024	3,196.00	3,368.22	172.22	5.11
Nov 2024	2,999.00	3,298.49	299.49	9.08
Dec 2024	3,170.00	3,461.02	291.02	8.41
Total Sep-Dec	**15,956.00**	**16,754.87**	**798.87**	**4.77**
Jan 2025	3,352.00	3,533.59	181.59	5.14
Feb 2025	3,162.00	3,264.99	102.99	3.15
Mar 2025	3,557.00	3,657.42	100.42	2.75
Apr 2025	3,480.00	3,544.26	64.26	1.81
Total Jan-Apr	**13,551.00**	**14,000.26**	**449.26**	**3.21**
Total Sep-Apr	**29,507.00**	**30,755.13**	**1,248.13**	**4.06**

Sources: Actual production values prior to September 2024 were obtained from USDA National Agricultural Statistical Service, Milk Production Survey.

California showed declines of 5.1% in October, 9.08% in November, and 8.4% in December as H5N1 hit California hard. The losses in California were enough to cause a slight decline in national milk production in November and December. Decline in milk production continued in through April of 2025, with a total of 4.1% of production lost for the months of September through April. The monthly and total values in this table are consistent with the values from our simulation model in Section 3 (Table 3.6), although the simulation model predicted larger losses in December and smaller losses in the first few months of 2025. In both cases, the total loss for the twelve-month period of August 2024 through July 2025 is on track to be around 3.5%.

Table 5.2 reports the implied production, and an estimate of production lost due to H5N1 in millions of hundredweight (cwt) for each month through April 2025, and the five-month total. The final column calculates losses of revenue by multiplying the reported California average monthly milk price by the production shortfall.

Table 5.2: Estimated Revenue Losses from H5N1 in California by Month

Month	CA statewide milk price (NASS)	Estimated Loss of Production	Estimated Loss of Revenue
	$/cwt	**Million Cwt**	**$ Million**
Sep 2024	23.8	0.36	8.60
Oct 2024	23.9	1.72	41.16
Nov 2024	23.7	2.99	70.98
Dec 2024	22.4	2.91	65.19
Total Sep-Dec		**7.99**	**185.93**
Jan 2025	22.7	1.82	41.22
Feb 2025	21.9	1.03	22.55
Mar 2025	20.7	1.00	20.79
Apr 2025	19.6	0.64	12.59
Total Jan-Apr		**4.49**	**97.16**
Total Sep-Apr		**12.48**	**283.09**

Sources: USDA National Agricultural Statistical Service, Agricultural Prices Survey - Prices Received for All Milk.

https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Milk/index.php

Table 5.2 shows that the total revenue loss for the nine months of the H5N1 outbreak is about $283 million, including more than $70 million in November and more than $65 million in December. The lost production average in those months exceeded 8%. Losses continued to decline gradually over the next four months until April 2025.

Table 5.2 shows only losses of revenue based on average prices and statewide production. We understand that H5N1 has mainly struck in the San Joaquin Valley where herds are large and milk production per cow is relatively high. Based on regional production data, we expect that H5N1 has infected herds with more than 90% of California milk production, with the remaining almost 25% of herds in the Sacramento Valley, the North Coast region, and Southern California.

The calculations in Table 5.2 assume that the average California milk price applied to the herds that had occurrences of H5N1 the price was not affected by H5N1 either directed or by reducing the quantity of California milk. A comparison of the average price of California milk relative to prices in other states shows no indication of an increase due to production shortfalls. This is also consistent with the data from the California Federal milk marketing order and with the nature of markets for California-produced dairy products that enter a large competitive national and global distribution. Simply put, most California milk, especially that produced in the San Joaquin Valley, faces markets where declines of 5% or even 10% in the quantity of farm milk do not cause a higher farm price.

We also considered the impact of lower milk production and perhaps slightly lower feed demand (due to the number of sick cows) on the prices of dairy feeds. We found no indication of lower prices of hay or silage, the two main feeds that are sourced locally.

Overall, H5N1 has raised dairy costs due to higher labor use and other costs to help cows recover. Although cow deaths have been uncommon, deaths and premature culling have added to costs, as has increased spontaneous abortion. These impacts of H5N1 have been particularly costly with higher prices of beef and costs of replacement heifers. Increased demand for replacement heifers has also likely reduced the quality of cows retained and replacement heifers entering the herd, both indicating lower productivity over the next few years as the industry recovers from lasting effects. We have not yet estimated the quantitative impacts of these negative impacts of H5N1.

Discussion

H5N1 has spread through herds that produce over 90% of California milk and in some months caused aggregate production to drop by 8 to over 9%. We estimate that from September 2024 to April 2025, total production in California dropped by about 4% due to H5N1, which translates to a loss of about $283 million in revenue. However, unlike the price of eggs, the price of milk has not increased to offset production shortfalls. The main effect of H5N1 in the dairy sector has been the loss of net returns for California dairy farms from the increased costs of managing the affected cows, the costs of quarantine, and the loss of production which, for an individual herd, can drop by over 15% in the first few weeks following the infection. Much is still being learned about how the disease will affect the dairy sector as H5N1 spreads to other states. This paper outlines several methods that can be used to assess the impact of H5N1 on the dairy industry, with more research underway.

References

Baker, A. L., Arruda, B., Palmer, M. V., Boggiatto, P., Sarlo Davila, K., Buckley, A., Ciacci Zanella, G., Snyder, C. A., Anderson, T. K., Hutter, C. R., Nguyen, T.-Q., Markin, A., Lantz, K., Posey, E. A., Kim Torchetti, M., Robbe-Austerman, S., Magstadt, D. R., & Gorden, P. J. (2025). Dairy cows inoculated with highly pathogenic avian influenza virus H5N1. *Nature*, *637*(8047), 913–920. https://doi.org/10.1038/s41586-024-08166-6

Morel, G., Pham, A., Morgenstern, C., Hicks, J., Rawson, T., Fan, V., Edmunds, W. J., Forchini, G., & Hauck, K. (2025). *The Impact of H5N1 on US Domestic and International Dairy Markets* (SSRN Scholarly Paper No. 5101058). Social Science Research Network. https://doi.org/10.2139/ssrn.5101058

Peña-Mosca, F., Frye, E. A., MacLachlan, M., Rebelo, A. R., Oliveira, P. S. B. de, Nooruzzaman, M., Koscielny, M. P., Zurakowski, M., Lieberman, Z. R., Leone, W. M., Elvinger, F., Nydam, D. V., & Diel, D. G. (2025). *The impact of influenza A H5N1 virus infection in dairy cows*. Research Square. https://doi.org/10.21203/rs.3.rs-6101018/v1

Rodriguez, Z., O'Connor, A., Bradford, B. J., & Picasso-Risso, C. (2025). Characterization and health, productivity, and economic effects of highly pathogenic avian influenza H5N1 outbreak in dairy cattle. *Journal of Dairy Science*, *108*(6), 6349–6358. https://doi.org/10.3168/jds.2025-26377

United States Department of Agriculture National Agricultural Statistical Services (USDA/NASS) Agricultural Prices Survey – Prices Received for All Milk. Available at: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Milk/index.php

United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS). Available at: https://www.aphis.usda.gov/livestock-poultry-disease/avian/avian-influenza/hpai-detections/hpai-confirmed-cases-livestock