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MILK YIELD AS A FACTOR IN DAIRY
HERD MANAGEMENT BY EXCEPTION

BY

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B.S., Washington State University, 1964
M.S., Washington State University, 1969

THESIS

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for the degree of Doctor of Philosophy in Agricultural Engineering
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CHAPTER I

INTRODUCTION

Goals

A long-range goal of the research of which this study is a part is to develop a computer-based, management-by-exception system for use in managing a production dairy herd. Management by exception is the use of equipment and analysis techniques to detect those animals which are exceptions; i.e., those that are not performing normally. Specifically, the objective is to use automatic data-acquisition and automatic data-processing equipment to analyze the performance of dairy cows on a daily or twice-daily basis. The analysis will determine which cows are below normal and call them to the attention of the dairy manager.

The short-range goal of the research, and the main thrust of this study, was to develop a basis for the implementation of the concept of management by exception for dairy cows. This goal was to be accomplished by using the digital computer and historical data to implement and test the concept.

Preliminary Investigations

In order to implement the management-by-exception concept, it was necessary to decide what physiological variables must be used and to

develop a model that would predict normal dairy cow performance based on these variables.

The main product of a dairy enterprise is milk. The amount of milk produced is dependent upon the cow's inherent milk-producing ability, her feed intake (quantity and quality), her environment, health, stage of lactation, whether pregnant, water intake, milking equipment, and handling by the milker. The earnings for the dairy enterprise are, in turn, dependent upon the milk production, feed costs, labor costs, overhead, maintenance, energy costs, veterinary costs, management costs, miscellaneous costs, milk price, and miscellaneous income.

The following quote is rather appropriate to the situation. "If there were not many environmental factors difficult to correct for, theoretical curves or charts might be prepared to check the expected production of any animal under comparable conditions" (Espe and Smith, 1952). One could develop a model based upon all the above variables; indeed, a dynamic simulation model to reproduce or project the behavior characteristics of the dairy cow. In fact, this approach was examined. Dynamic energy models for beef and dairy cattle (Witz, 1972, and Keener, 1973) were studied, but that approach did not appear to get down to the basic problem of testing the concept of management by exception in a real dairy situation.

To test the concept, the approach taken was to study patterns of variation in variables that are or may be practical diagnostic indicators for the dairyman or veterinarian. Such variables are daily milk production, body weight, feed intake, water consumption, body temperature, and possibly milk conductivity, ambient temperature, relative humidity, wind velocity, and precipitation. How valuable would daily monitoring of each

of these be? It was soon apparent that to answer that question was beyond the scope of this study because several years would be required to evaluate all of them.

Since milk production is the prime objective of the dairy enterprise, it is easily one of the most important of the variables from the practical standpoint. Body temperature has long been used to diagnose illness, and would be relatively simple to monitor in the milking parlor. (Commercial devices are presently available that monitor milk temperature as an indication of body temperature and give alarm by sounding a buzzer or flashing a light if milk temperature rises above a designated level.) Weather conditions could also be monitored and entered into the analysis. Body weight could be monitored, but it can be quite variable and the changes may lag behind the cow's problems; hence, the value of body weight records in predicting problems before they become severe is questionable. Feed and water consumption may not be easily monitored, because in a practical commercial dairy enterprise, the animals are housed in groups. However, the electronic individual feeding system (Hyde, et al., 1974) studied at the University of Illinois may make it possible to monitor concentrate consumption.

Milk conductivity would be relatively easy to monitor automatically in the milking parlor. It is well established that mastitis causes a rise in milk sodium and chloride and a fall in potassium and lactose, the net result being an increase in electrical conductivity (Linzell, et al., 1972). Greatrix, et al. (1968), found good correlation between leucocyte cell count and the relative electrical conductivity of milk from individual quarters. Those authors suggest that regular monitoring of milk conductivity could detect subclinical mastitis with a fairly high efficacy. Linzell,

et al. (1972), show that variation of electrical conductivity among quarters can be a sensitive index of subclinical and clinical mastitis.

This discussion leads to three variables--milk yield, milk temperature, and milk conductivity--which appear to have the attributes of being both practical to monitor in the milking parlor and of value in a management-by-exception system. Of these three, milk yield is probably the most important to the dairy manager because it is his end product and he needs accurate records of it for culling and other purposes. So, of all the variables, it appears that one should first examine daily milk yield to see if it can be used to predict dairy cow performance and to indicate potential problems so that the dairy manager may take preventive measures. Milk yield analysis could call attention to problems; then data on body temperature and/or milk conductivity could be used for diagnoses of the problems.

CHAPTER II

LITERATURE REVIEW AND CONSULTATIONS

Lactation Curves and Equations

How does one analyze patterns of daily milk yield to determine whether a cow is performing normally? A preliminary step is to study patterns for cows considered to have performed normally.

The lactation curve for dairy cows (daily yield vs. time in days over the entire lactation) is discussed in the literature. Turner, et al. (1923), used analysis of historical data to show that the location of the peak of the lactation curve varied from 15 days after calving for cows milked twice daily to 28 days after calving for cows milked four times a day. That work also showed that production declined after the peak to about 94 percent per month of the previous month's yield for nonpregnant Guernsey cows and proposed the equation

$$m_t = m_o e^{-kt} \quad (1)$$

for the declining part of the curve, where m_t is milk produced during any month of the lactation period t , m_o is initial theoretical production, k is the persistency constant and t is time in months. Based on these data, Brody (1945) proposed the following three equations to describe the entire lactation curve for four, three, and two milkings per day. Figure 1 is a plot of these equations.

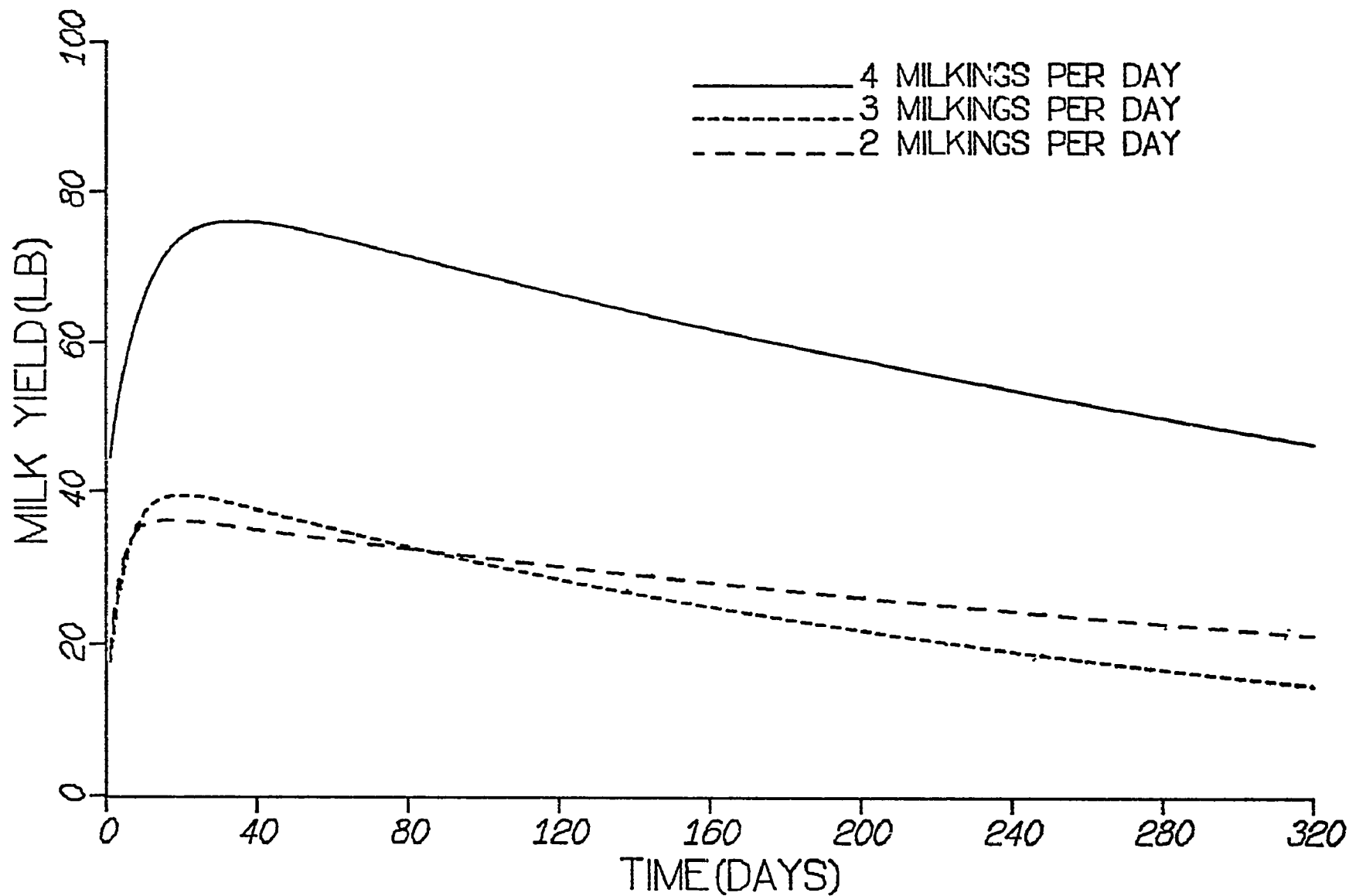


Figure 1. Plot of Three Lactation Curve Equations from Brody (1945).

Milkings
per day

$$\begin{aligned}
 4 \quad m_t &= 41.6 (1.98e^{-.0018t^*} - e^{-.0988t}) \\
 3 \quad m_t &= 30.6 (1.41e^{-.0034t} - e^{-.1882t}) \\
 2 \quad m_t &= 25.1 (1.50e^{-.0018t} - e^{-.2963t})
 \end{aligned} \tag{2}$$

More recently, Wood (1967) statistically fitted lactation curves using an equation of the form

$$y_n = An^b e^{-cn} \tag{3}$$

where y_n is the average daily yield in the n th week; A , b , and c are regression coefficients; e is the base of the Napierian logarithm; and n is time in weeks. The peak of this curve (see Appendix A for derivation) occurs at $n = b/c$. Equation (3) is particularly well suited for statistical analyses because it can be transformed into an equation with linear coefficients by taking the logarithm of both sides

$$\ln y_n = \ln A + b \ln n - cn.$$

Then, multiple linear regression can be used with the independent variables being n and $\ln n$.

*This exponent was .018 (Brody, 1945), but was apparently a typographical error because .018 gives a peak day of 12.6 days while .0018 gives a peak at 34 days which agrees more closely to the 28 days reported by Turner, et al. (1923). Another error apparently exists in one of the first two equations because the three-milkings-per-day curve should lie between the other two and because the magnitude of the four-milkings-per day curve appears to be too large. However, the source of that error was not readily determined.

Wood (1968) also discussed persistency as a function of sire progeny groups and parity (lactation number), and (1969) effects on curve shape of month of calving and parity. He also was able to confirm the efficiency of the model by the low value of residual standard deviation about the curve of ± 17.5 percent.

Wood (1970) states that, ". . . variations in the shape [of the curve] from one herd to another are relatively unimportant: indeed, 77.4 percent of the total variation in this sample was associated with parity and season of calving, 17.2 percent with differences between cows, and only 5.4 percent with herds." In his conclusion he states that "one can infer with some confidence . . . that curve shape remains relatively unaffected by variation in management, including the service interval. The most important sources [of variation] were parity and season of calving, so that a predictive model founded upon month/parity subclasses may be expected, in general, to be accurate."

Wood (1972) noted that the shape of the lactation curve did not change significantly with season of calving, once effects of parity were accounted for, when cows were fed silage in confinement and did not get fresh grass in the spring. This finding was based on data from 161 lactations in Great Britain.

More recently Schultz (1974) used the same equation (except that time was in days) to fit curves to 1,706 lactations from DHIA once-a-month data in 36 subclasses of three parities, six seasons of calving, and two days-open categories. These data were from official DHI records over the period September, 1965, through January, 1969. The resulting values for A, b, and c (see equation (3)) are similar to those of Wood (1967, 1968, 1969). His

work also showed that days-dry had only a slight effect on the shape of the curve and rolling herd average had no effect on curve shape.

If monitoring of dairy cows by comparing their performance to a standardized curve proves useful, the standardized curve might well be based on the same equation used in these references because that equation fits the lactation curve well.

Other methods of comparison might be to compare each cow to a running average of her performance over the immediately preceding several days, or to a percentage of the average daily yield during the previous week (Price, 1975; Seldown Electronics, 1974).

Influence of Cow Age on Lactation Curve Shape

Many studies have been made on the effects of cow age at calving on lactation (Burnside, 1974; Lee, 1974; Freeman, 1973; Hickman, 1973; Miller, 1973; McDaniel, 1973; Erb and Ashworth, 1961; Van Vleck and Henderson, 1961b), but these works examine effects on the total lactation yield, not the shape of the lactation curve. The primary purpose of the above studies was to aid in accurately extending incomplete lactation records for herd improvement and sire evaluation. Burnside (1974) showed that, after the effects of season of calving are eliminated, the trend in total yield per lactation is upward until the cow reaches approximately 70 months of age. Lee (1974) showed that for first lactation cows the total milk yield varied from minus 400 to plus 250 kilograms about the mean for a range in age at calving of 24 to 36 months. This variation is approximately minus 8 percent to plus 5 percent of the mean total yield, with the older cows producing more milk.

Van Vleck and Henderson (1961b) showed that, for test-day milk yield, the F values are significant at the 1 percent level for the effects of age at calving, season of calving, month of lactation, and the age-by-season, age-by-month of lactation, and season-by-month of lactation interactions. The age-by-season-by-month interaction was not significant. The authors concluded that the analyses ". . . seem definitely to imply that ratio factors (1) for adjusting monthly records to a common age and season, (2) for estimating a total lactation from a single monthly record, and (3) for estimating a total lactation from cumulative monthly records may be constructed while simultaneously taking into account the age at calving, season of calving, month of production, and whether the record is fat or milk."

Parity was not discussed in the article; however, the age effects were similar to parity effects in that the lactation curve peaks higher and declines faster for the older compared to the younger cow.

Influence of Parity (Lactation Number) on Lactation Curve Shape

Wood (1969) showed that the lactation curve tends to peak higher and decline faster for older cows; i.e., younger cows are more persistent but do not peak as high. Schultz (1974) noted this trend also and gave other references that confirmed it. However, if one plots regression curves based on the coefficients for lactations 1, 2, and 3 or more, determined by Schultz (1974) and adjusts the A parameter in equation (3) to give equal total yield (equal area under the curve) for each curve, it is easily seen that parity 2 and 3 curves are nearly the same while the parity 1 curve peaks lower and is more persistent (see Figure 2).

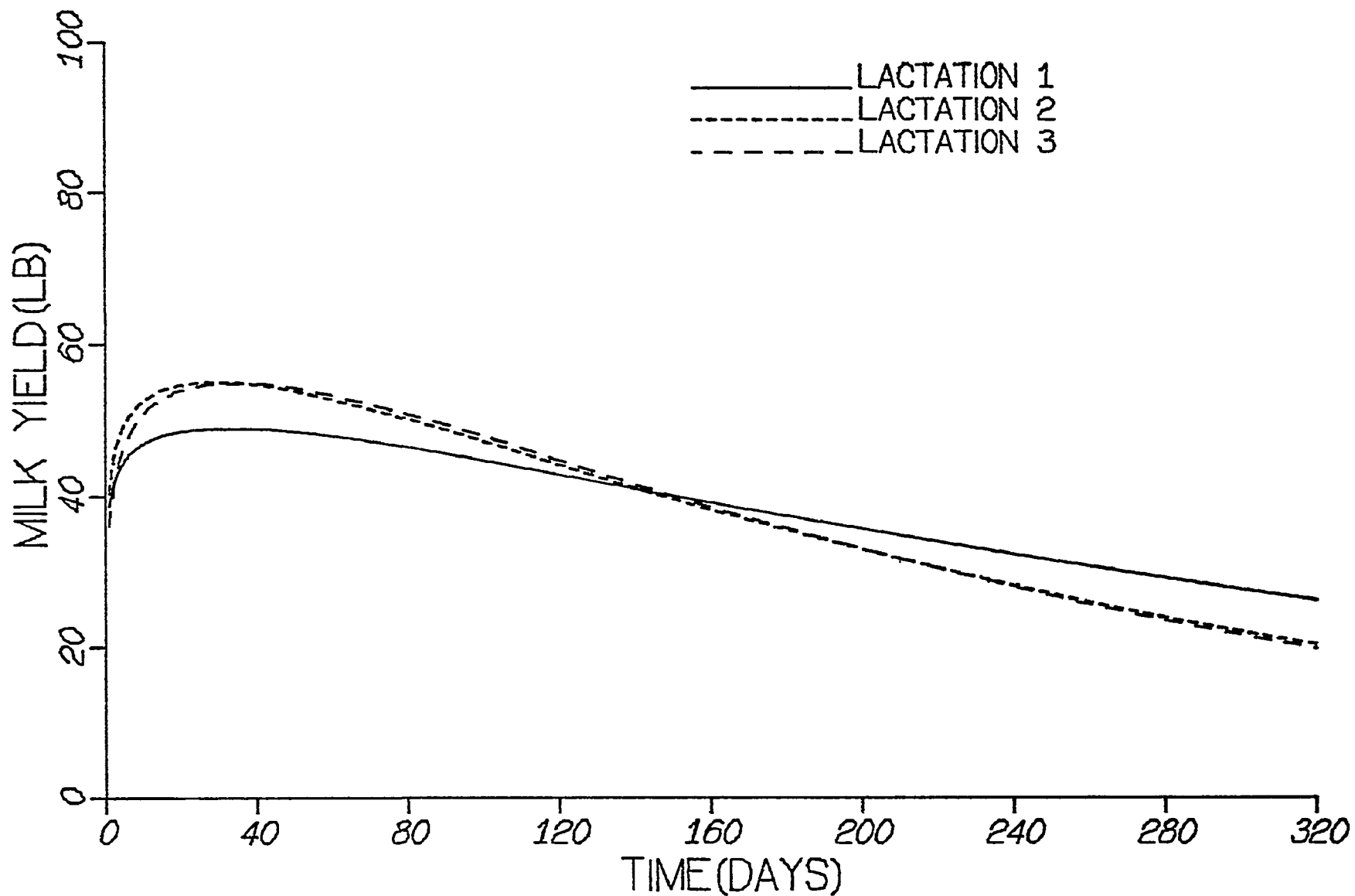


Figure 2. Plot of Three Lactation Curve Equations from Schultz (1974) for Parities 1, 2, and 3 with Total Yields Adjusted to 12,000 lb. for Each.

Influence of Seasonality on Lactation Curve Shape

Burnside (1974) showed that total production for all age groups is lowest for those calving in the summer months (June, July, August) and highest for those calving in October through January for Canadian cows. Van Vleck and Henderson (1961b) also found that season of calving had a significant effect on total lactation yield. Wood (1969), working with dairy herds in Great Britain, divides the effect of seasonality into two parts, ". . . (1) a stimulus to milk production associated with the season of production, which is referred to as spring hump seasonality, and (2) an effect on total yield, independent of the spring hump, associated with that period of the year in which the lactation occurs (it is generally recognized for instance that winter calvers have higher average yields than summer calvers)." Wood referred to the second effect as calving month seasonality to distinguish it from spring hump seasonality. He showed that spring hump seasonality is independent of parity and of calving month seasonality and (Wood, 1970) that the pattern of spring hump seasonality was similar over years. Wood (1972) studied records from 161 lactations completed in the year ending September, 1969, from a herd of British Friesians kept indoors all year round and fed grass silage with a concentrate supplement. Seasonal variation in milk production for that herd was compared to that of cattle traditionally managed in Great Britain. After allowing for variation due to parity, season of calving, and stage of lactation, there was a tendency for milk production to be stimulated during periods of feeding grass preserved in a rapidly growing state (i.e., silage made from spring-time grass). Spring hump seasonal variation was much less evident in the indoor herd than in traditionally managed herds. Therefore,

confinement herds in the United States that are fed silage year round may also display less spring hump seasonality in milk production than pastured herds.

Influence of Days-Open on Lactation Curve Shape

Results from Schultz (1974) show that cows open (i.e., not pregnant) more than 139 days produced a significantly greater proportion of their total yield during months 9 and 10 than did cows open less than 70 days. The majority of differences in lactation curve shape among the days-open groups occurred during the last two months of lactation. The effect of pregnancy was not noticeable at all before six months into gestation. Corley (1956) and other references (see Schultz, 1974, for literature review) agree that neither persistency nor total yield is appreciably influenced by pregnancy during the first five months of gestation.

Consultations

Many discussions took place during the initial stages of this work. Several hours were spent discussing the many possible approaches with Drs. K. E. Harshbarger and S. L. Spahr of the Dairy Science Department and Dr. S. E. Curtis of the Animal Science Department, University of Illinois, and four days were spent talking with U. S. Department of Agriculture, Agricultural Research Service personnel at Beltsville, Maryland, particularly dairy research personnel, about possible methods of implementing management by exception.

The discussions at Beltsville pointed out that there are two kinds of problems to be detected in dairy cows: acute, and (the more difficult to detect) chronic. The idea of using each cow as her own control by using running average comparisons was thought to have more promise than comparison to a standardized curve.

The matter was discussed at length also with Dr. George E. Shook of the Dairy Science Department at the University of Wisconsin. Dr. Shook was the advisor to Allen Arthur Schultz on his thesis (Schultz, 1974), and was enthusiastic about comparing daily yields to a standardized curve. He graciously provided results of a statistical analysis (Shook, 1975) that gave day-to-day standard deviations among days within cows which are used in some of the analyses in this study.

CHAPTER III

PRELIMINARY DATA WORK

After the literature review and discussions of the last chapter and considerations of what data and information were available, it was decided that the best first step in the implementation of management by exception was to investigate milk yield patterns to determine the maximum amount of information they could yield.

Milk Yield Records

Daily milk yields on nearly 600 lactations from the Beltsville herd of Holsteins were acquired on loan on magnetic tape with the gracious help of Dr. Ronald E. Pearson, along with clinic record sheets on 170 of those same lactations. The taped lactation records contained complete animal identification, including numerical codes for herd, breed, cow number, parity, calving date, date of record, milking interval, cow age in months, card image number, and A.M. and P.M. milk weights in pounds for eight days per card image with four cards per month. The data format used was a compact one for storage, but difficult to use in that form; therefore, one of the first tasks was to develop computer programming to transform the data into a format that would provide one record for each day of the lactation and calculate that lactation day from the calving date data. A program was

developed to convert to five-digit Julian dates and calculate the day of lactation for each data value (see Appendix B for flow diagram and program listing) and make adjustments for month-length, year-end, and leap year.

Preliminary Plotting

While in the process of developing programs to manipulate the large Beltsville data set, it became apparent that a small data set was needed to make trial runs of programs. Barn sheet data from five cows at the University of Illinois dairy at Urbana were recorded on punch cards to serve as the small data set. Figures 3 through 7 are computer plots of these five lactations along with comparison limits for one of the analysis methods to be discussed later. These figures illustrate the two types of problems that need to be detected for management by exception: acute problems causing sudden drops in production (cow number 2901, Figure 4), and chronic problems that cause a gradual decline in production that is faster than the normal rate of decline (cow number 2747, Figure 3).

Regression Analyses

Once the tape data were converted to day-of-lactation form and stored on tape, they could be used for plotting, regression analysis, and other analyses requiring correspondence between daily yield and day of lactation. The original Beltsville tape contained 23,423 records (card images) each 80 characters long; the conversion to day of lactation meant the new tape file was approximately eight times longer because it contained one day per record instead of eight. So the new tape contained approximately 187,000 records that were each 35 characters in length.

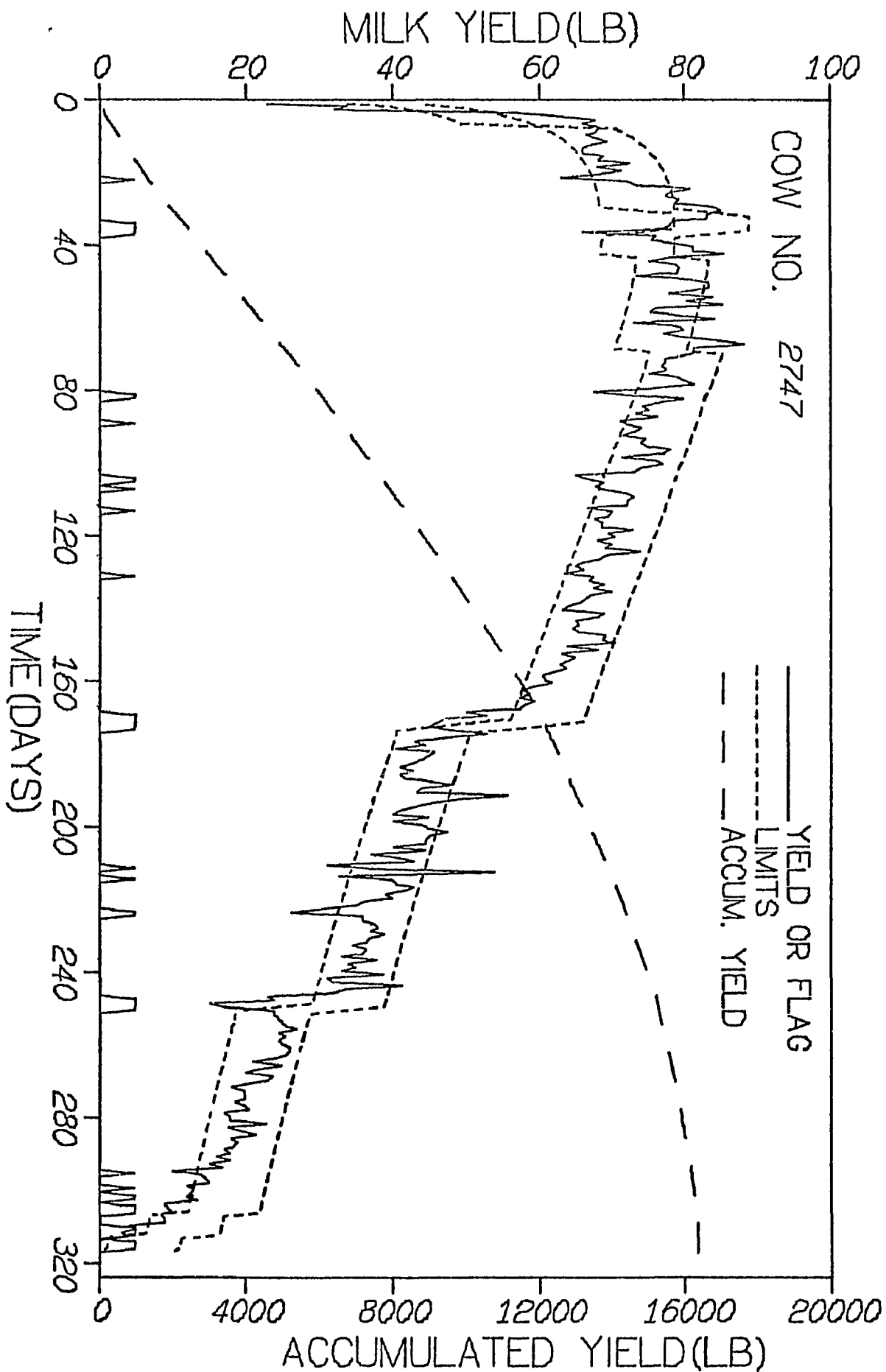


Figure 3. Lactation Curve with ± 5 -lb. Regression Limits for One of Five University of Illinois Cows Freshening Early in 1974.

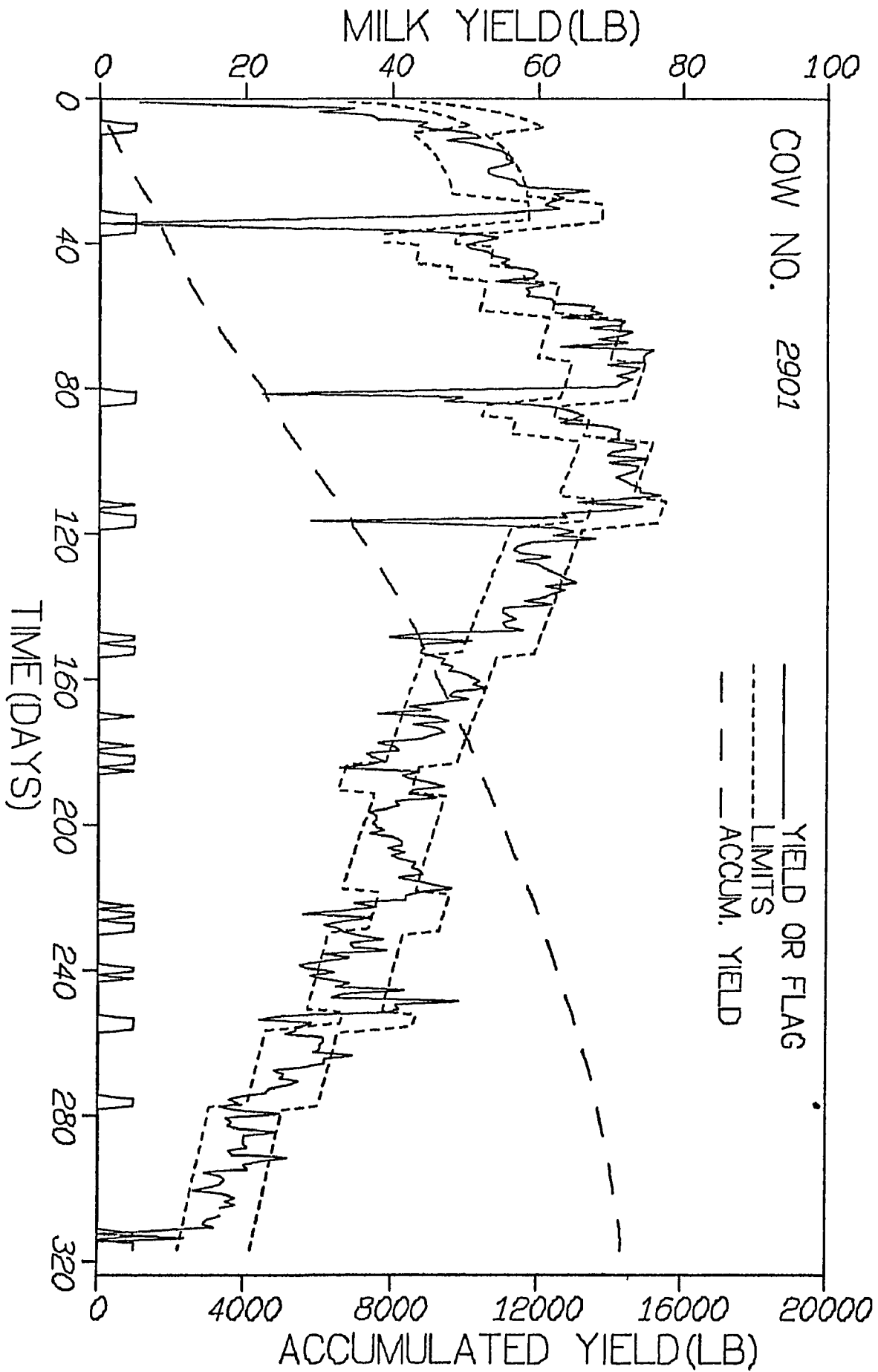


Figure 4. Lactation Curve with ± 5 -lb. Regression Limits for One of Five University of Illinois Cows Freshening Early in 1974.

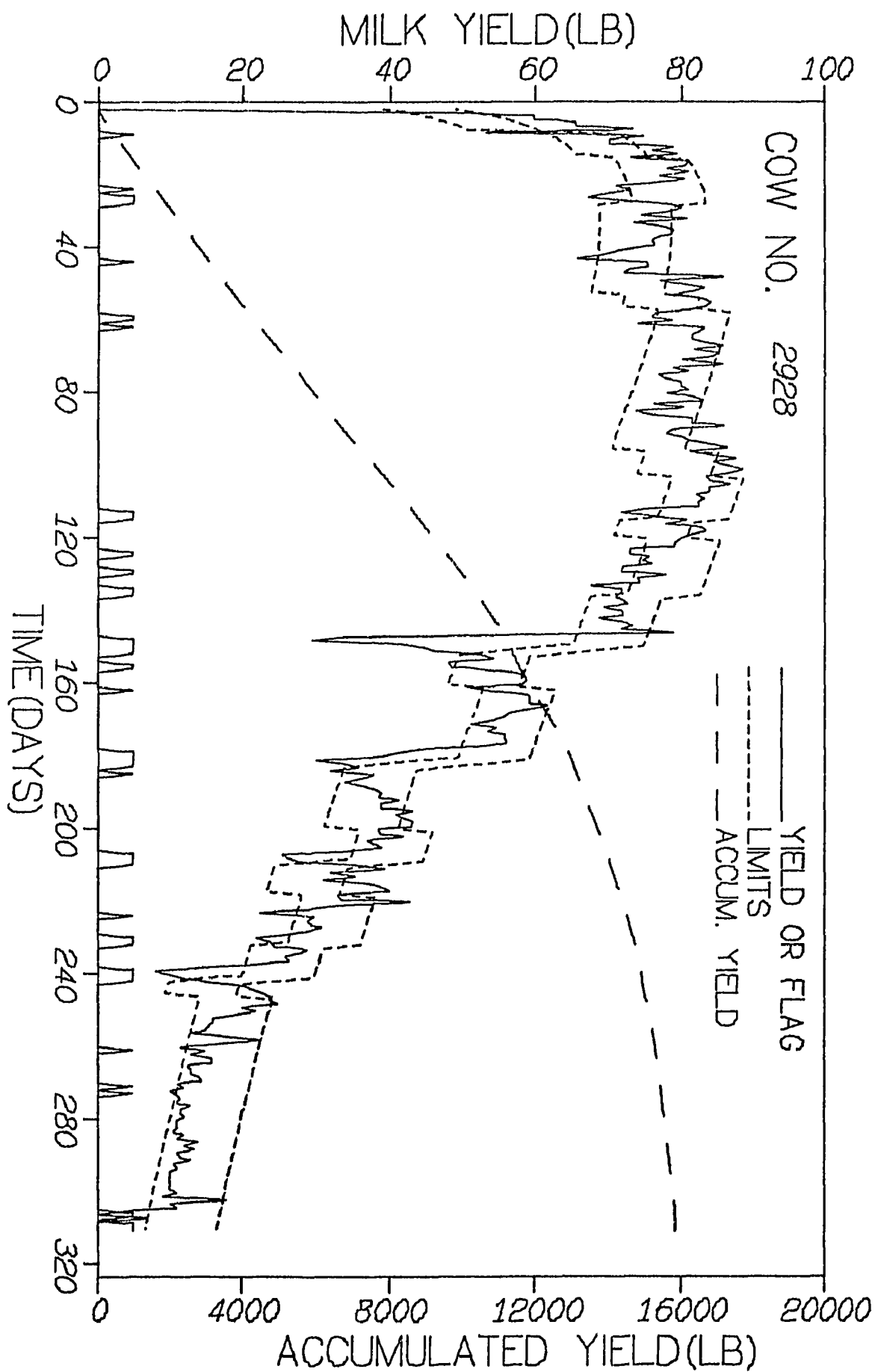


Figure 5. Lactation Curve with ± 5 -lb. Regression Limits for One of Five University of Illinois Cows Freshening Early in 1974.

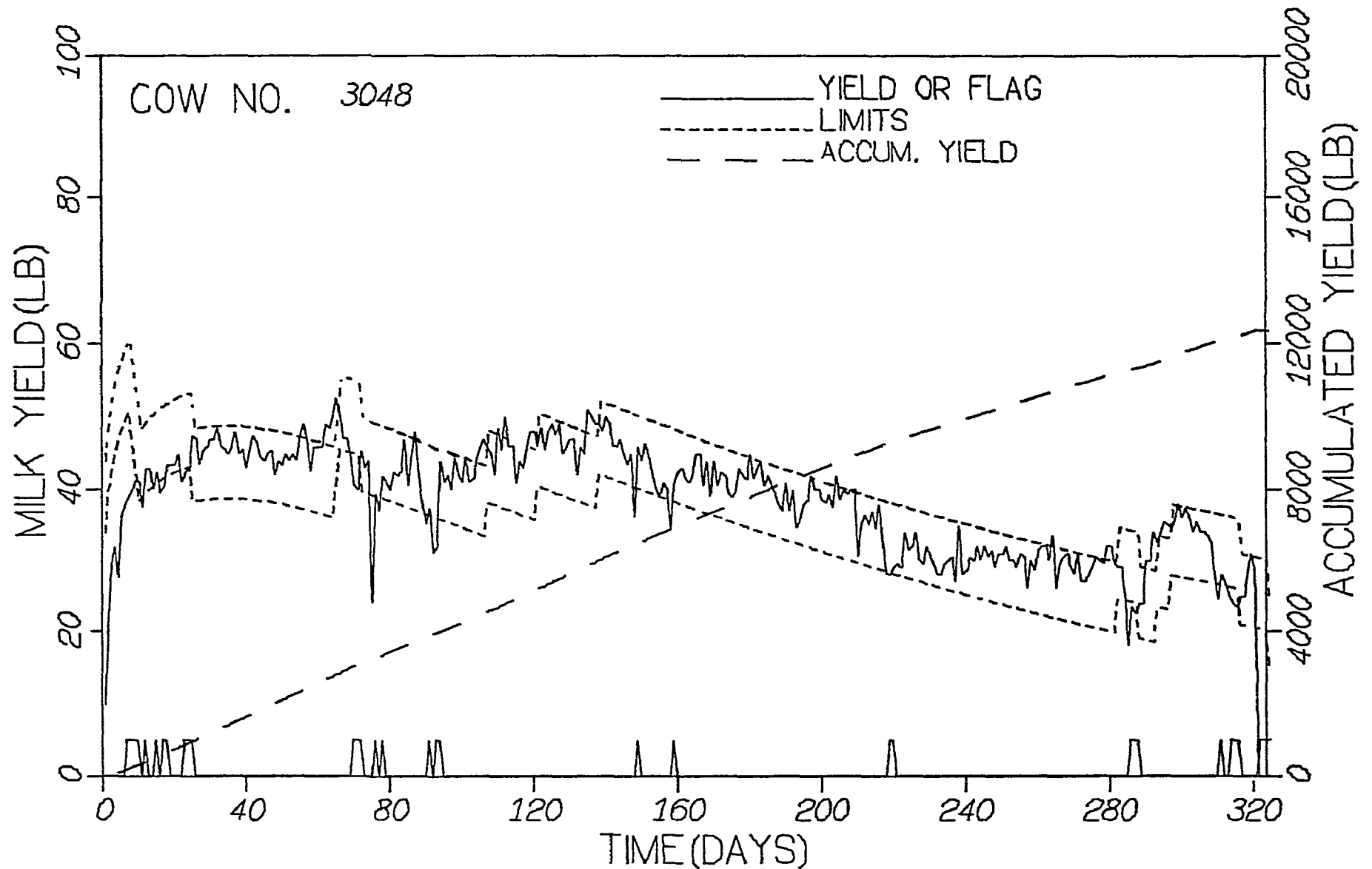


Figure 6. Lactation Curve with ± 5 -lb. Regression Limits for One of Five University of Illinois Cows Freshening Early in 1974.

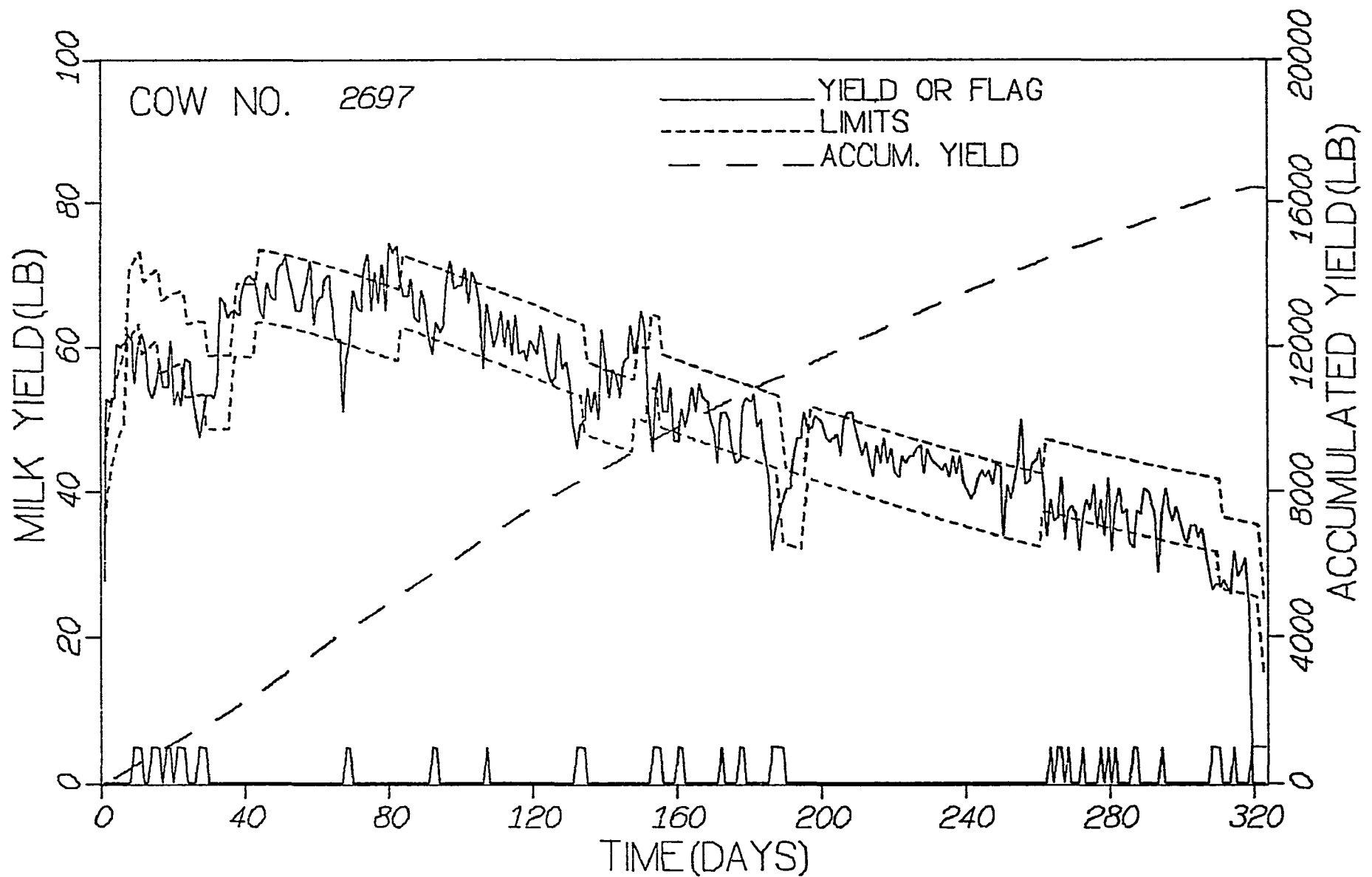


Figure 7. Lactation Curve with ± 5 -lb. Regression Limits for One of Five University of Illinois Cows Freshening early in 1974.

The next step was to do frequency counts of the lactations in the data to determine how they might be grouped according to parity, age within parity, and season of calving. Table 1 shows the grouping chosen and the number of cows in each of the 36 subclasses. The subclasses consisted of three parities, three age groups within each parity, and four seasons of calving where season one included January, February, and March, season two included April, May, and June, and so on. The fact that there was only one cow in one of the subclasses was acceptable because the subclasses were to be combined later after regression analysis indicated which were significantly different.

Table 1. Numbers of Lactations in Each of the 36 Subclasses

Parity	Age Group	Season			
		1	2	3	4
1	1 (22-24mo)	35	23	24	37
	2 (25-27mo)	28	28	35	42
	3 (28-30mo)	3	10	9	6
2	4 (35-37mo)	22	8	14	24
	5 (38-40mo)	13	16	12	24
	6 (41-43mo)	3	8	6	9
3	7 (48-50mo)	11	13	15	22
	8 (51-53mo)	6	10	8	18
	9 (54-56mo)	3	5	15	1

Next the entire 187,000-record data-set was grouped according to the 36 subclasses, then sorted by parity, age group within parity, season of calving, cow number, and day of lactation. The grouping and conversion routines were written in FORTRAN (see Appendix B for listings and flow diagram of the conversion routine) and the IBM SORT/MERGE routine was used for sorting.

Next, regression analyses were run on the 36 subclasses. The resulting regression coefficients along with other pertinent data are given in Table 2. These computations were done using the SAS (Statistical Analysis System) routine available at the University of Illinois computing facilities (Service, et al., 1972).

Heterogeneity Test

After the regression coefficients were obtained, the next question was which of these subclasses are significantly different from the others? The answer was determined by testing the heterogeneity of the regression coefficients (Lee, 1975). The primary interest was in the shape of the curve rather than its magnitude, and this test determines differences between the shape coefficients "b" and "c" without regard to the magnitude coefficient "a" (Steel and Torrie, 1969) (see Table 2). To do the heterogeneity analysis it was necessary to run an overall regression, regressions by parity, by age group, by season, and by parity and season. The latter two required that the data be re-sorted by season, parity, age group, cow, and day of lactation so that regressions by season could be run. The regression sums of squares from each of these analyses were then used to calculate heterogeneities as shown in Table 3.

Table 2. Regression Coefficients a, b, and c for 36 Subclasses of 3 Parities, 3 Age Groups within Each Parity, and 4 Seasons of Calving, for the Model $\ln y = a + b \ln t - ct$.

Parity	Age Group	Coefficient	Season			
			1	2	3	4
1	1	a	3.260	3.320	3.344	3.413
		b	0.196	0.149	0.134	0.154
		c	0.00367	0.00293	0.00260	0.00290
		error df	10643	6706	7012	10,976
	2	a	3.485	3.326	3.392	3.448
		b	0.151	0.166	0.129	0.141
		c	0.00320	0.00350	0.00263	0.00309
		error df	8417	8536	10,688	12,817
	3	a	3.417	3.206	3.428	3.405
		b	0.166	0.219	0.151	0.143
		c	0.00332	0.00406	0.00260	0.00336
		error df	913	3047	2437	1827
2	4	a	3.598	3.770	3.764	3.665
		b	0.213	0.092	0.100	0.187
		c	0.00597	0.00420	0.00449	0.00501
		error df	6620	2354	4220	7298
	5	a	4.047	3.849	3.740	3.658
		b	0.100	0.116	0.132	0.201
		c	0.00439	0.00364	0.00490	0.00541
		error df	3854	4863	3595	7277
	6	a	3.970	3.745	3.415	3.777
		b	0.137	0.180	0.234	0.169
		c	0.00363	0.00446	0.00484	0.00549
		error df	912	2416	1826	2705
3	7	a	3.772	3.737	3.333	3.859
		b	0.195	0.179	0.244	0.168
		c	0.00596	0.00547	0.00488	0.00519
		error df	2342	2126	2437	3652
	8	a	3.757	3.580	3.871	3.786
		b	0.189	0.219	0.103	0.194
		c	0.00505	0.00424	0.00425	0.00610
		error df	1786	2129	1166	4493
	9	a	4.000	3.822	3.985	4.126
		b	0.127	0.188	0.082	0.113
		c	0.00389	0.00440	0.00320	0.00343
		error df	607	1217	2985	302

Table 3. Heterogeneity of Lactation Curve Regression Coefficients.

	SS	df	MS	F
<u>Heterogeneity of Season</u>				
4				
Σ Regr SS for each season	8008.1199	8		
- pooled overall cells SS	-7947.7559	-2		
	60.3640	6	10.06067	176.7
<u>Heterogeneity of parity</u>				
3				
Σ Regr SS each parity	8760.2822	6		
- pooled overall cells SS	-7947.7559	-2		
	812.5263	4	203.1316	3567.2
<u>Heterogeneity of age within parity</u>				
9				
Σ Regr SS for each age group	8816.0567	18		
-3 Σ Regr SS each parity	-8760.2822	-6		
	55.7745	12	4.6479	81.6
<u>Heterogeneity of parity X season</u>				
12				
Σ Regr SS for each parity and season	+8883.8483	24		
-3 Σ Regr SS each parity	-8760.2822	-6		
-4 Σ Regr SS each session	-8008.1199	-8		
+ pooled overall cells SS	+7947.7559	+2		
	63.2021	12	5.2668	92.49
<u>Heterogeneity of age X season within parity</u>				
36				
Σ Regr SS for each cell	9032.6772	36x2=72		
- Season Heterogeneity	-60.3640	-6		
- parity het	-812.5263	-4		
- age grp within parity het	-55.7745	12		
- parity x season het	-63.2021	12		
	-7947.7559	2		
	93.0544	36	2.5848	45.4

Error SS for F tests of above:

36

 Σ error SS for each cell = 8951.7679
error

 $n - 3 * 36 = 157201$
MS = .956945

All F's are highly significant.

The analysis showed that the coefficients for each of the factors of season, parity, and age within parity were highly heterogeneous as were the interactions of parity-by-season and age-by-season within parity. The "F" values (Table 3) show that the heterogeneities of the interactions and of age within parity may be weaker than for season and parity. Whether there are practical differences in curve shape among the factors in application to management by exception will be seen later.

Pooled Regression Coefficients

Table 4 gives regression coefficients from the analyses over all cells, by parity, by age group, and by season of calving. Calculated peak times of lactation are also tabulated. Note that these regression coefficients are based upon data for every day of each lactation, whereas previous works (Schultz, 1974; Wood, 1969-70) are based upon weekly or monthly samples of yields but for larger numbers of cows.

Yield and Clinic Record Data Set

The tests of whether there are practical differences among the regressions came later in the trials of various methods of analysis for management by exception. To conduct those trials it was necessary to have a data set containing daily milk yields plus day-to-day clinic records. Handwritten clinic sheets were graciously provided by Beltsville personnel (Pearson, 1975) on 100 of the cows whose yield records were contained in the taped data. The records of two or even three lactations for several of these cows were included in the data, so that both yield and

Table 4. Regression Coefficients Over All Cells, by Parity, by Age Group, and by Season of Calving for the Model
 $\ln y = a + b \ln t - ct.$

Regression	Coefficients			Peak day (b/c)
	a	b	c	
Across cells by parity	3.550	0.159	.00393	40.4
1	3.374	0.155	.00311	49.8
2	3.734	0.160	.00487	32.8
3	3.773	0.173	.00492	35.2
by age group within parity				
1	3.336	0.162	.00308	52.6
2	3.415	0.145	.00308	47.1
3	3.339	0.176	.00339	51.9
4	3.679	0.165	.00510	32.4
5	3.801	0.146	.00466	31.3
6	3.711	0.182	.00478	38.1
7	3.699	0.192	.00532	36.1
8	3.753	0.184	.00522	35.2
9	3.959	0.113	.00356	31.7
by season				
1	3.555	0.173	.00426	40.6
2	3.515	0.160	.00377	42.4
3	3.530	0.135	.00340	39.7
4	3.584	0.165	.00418	39.5

health information were available on approximately 170 lactations. The clinic sheets were studied one-by-one and the veterinarians' diagnoses were coded according to a numerical coding system used by Wolfe, et al. (1973). An additional code of 010 was added for the comment "down in milk" listed on the clinic sheets in some instances. The other codes were 100's for mammary problems, 200's for reproductive problems, 300's for metabolic problems, 400's for anatomical problems, and 600's for miscellaneous problems. These codes were punched on cards for each cow for each date that had an entry in the clinic records. Also on the card were cow identification, calving date, etc., as with the card images on the Beltsville tape. Then a modification of the program to convert from date to day-of-lactation was written to collate the clinic codes with the yield data for each day of the lactation for each cow. For the days of the lactations for which there were no clinic entries, a zero was entered in the clinic code data field. (The flow diagram and listing for this program are also in Appendix B.) The result of this programming was a taped data subset with clinic coding for every day of every lactation. This data set was to be used to test several analysis techniques to see which would do the best job of picking out cows with problems on the basis of daily milk yield information alone.

CHAPTER IV

METHODS OF COMPARISON

There are a multitude of ways that one might analyze patterns of daily (or twice daily) milk yield for dairy cows. One theory (Curtis, 1974) is that biological systems tend to fluctuate more widely when the organism is under stress. Hence, maybe daily milk yield fluctuates more widely when the cow has a physiological (or psychological) problem. This idea suggests examining the slope or rate of change of daily yield. However, Figures 5 through 10 show that the derivative of the lactation curve, or even a plot of differences from day-to-day, would fluctuate so widely that it would shed little light on the basic problem at hand. It is interesting to note that the integral of the lactation curve, which is approximated by the accumulated yield curve, is relatively a smooth curve as seen in Figures 3 through 7. The wide variations in day-to-day yields in the figures do not discredit the theory of the relationship between stress and yield variation, but the nature of the variations makes the use of derivatives or differences per se appear less acceptable than some other methods of analysis.

Running Averages

Other methods suggested include comparing a cow's daily yield to a running average of her past few days' yields. This method is akin to using

a smoothed or averaged derivative. It should be pointed out that using the infinitesimal increments of calculus methods is really not appropriate because the cow is not milked continuously but instead at finite intervals. Therefore, numerical methods using finite increments are better suited to this problem.

Periodically Updated Averages

A method used in England (Price, 1975) compares a cow's daily yield to a percentage of the average of the daily yields from the previous week. This calculation requires less computer memory than a running average and the comparison figure need be updated only once a week. Both of the above methods tend to follow gradual changes and to detect sudden changes, which means that they will tend to detect acute problems better than chronic problems. Figures 8 and 9 compare this method to a regression curve method for one cow. Note that the gradual, abnormal decline near the middle of the lactation was detected at day 172 by the 7-day average method (Figure 8), but at day 169 by the comparison to the standardized curve (Figure 9), an improvement of three days in heading off a potential problem.

Margin or Tolerance Limits

Another aspect of the problem is apparent in data graciously provided by Shook (1975) giving standard deviations among days within cows pooled across months, and coefficients of variation under the same conditions (Table 5). Note that the standard deviation is neither a fixed amount of

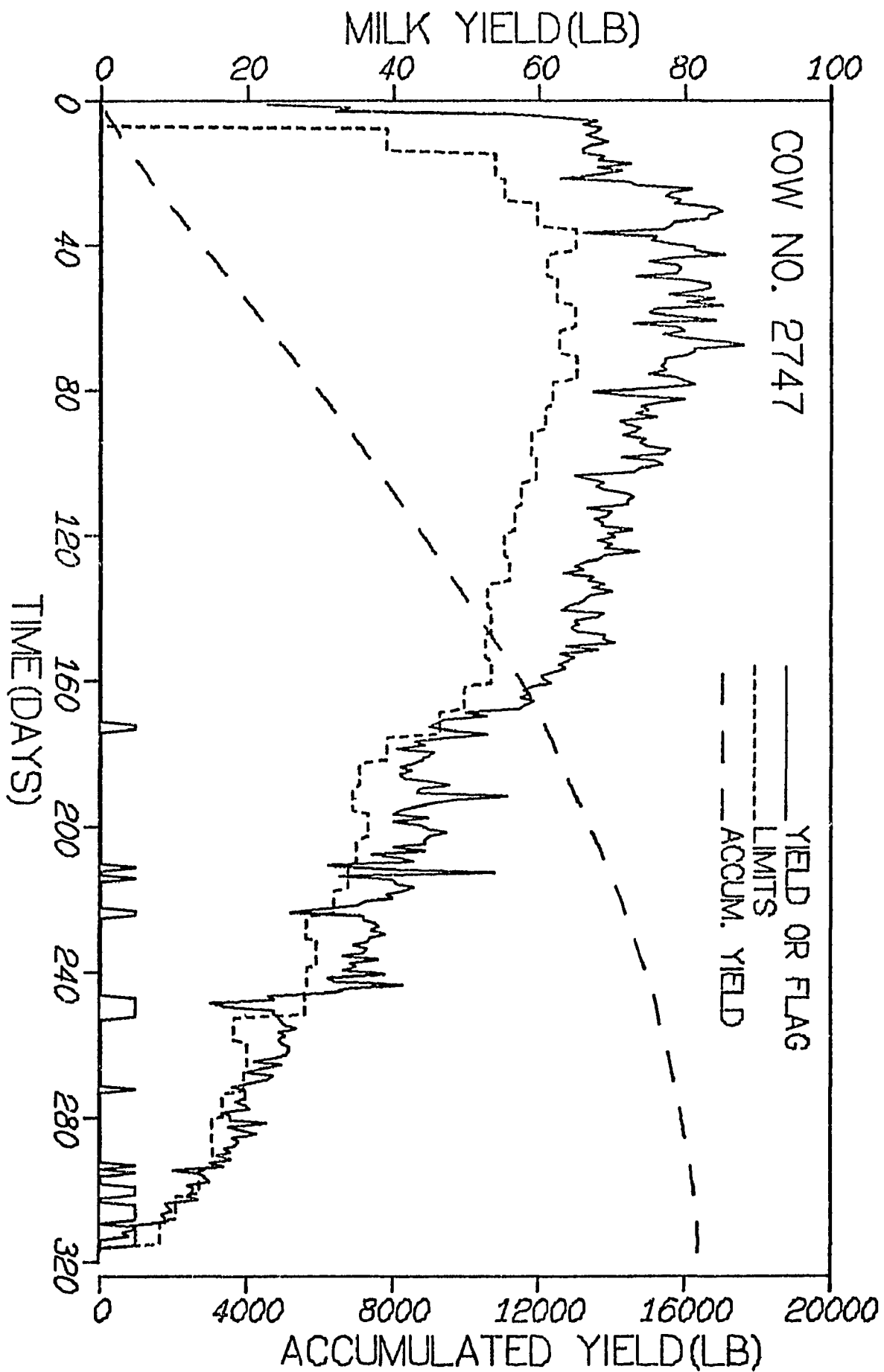


Figure 8. Lactation Curve with Limit Line Equal to 80% of the Average of the Previous Week's Daily Yield.

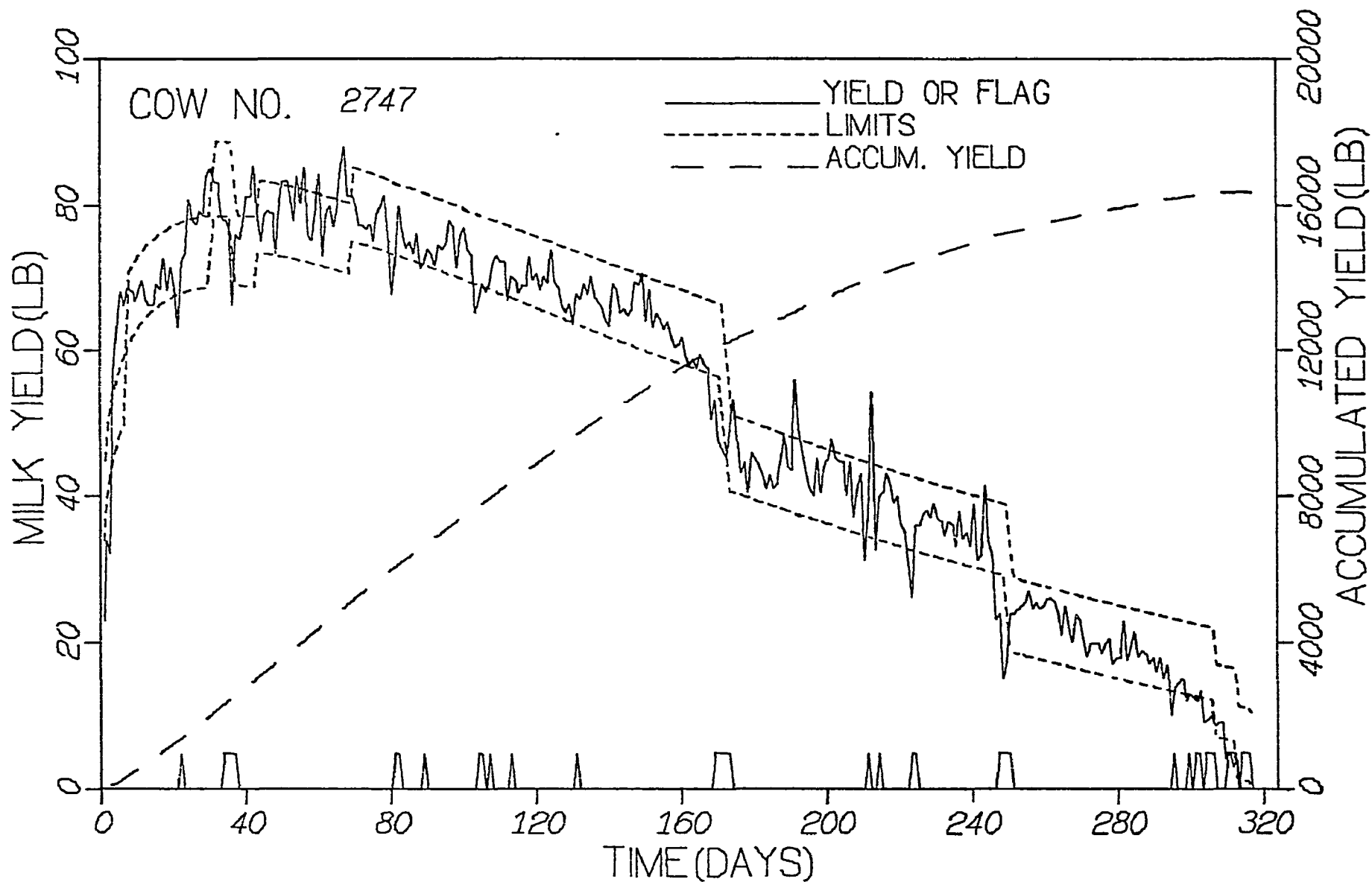


Figure 9. Lactation Curve with Limit Lines Based on a Regression Line ± 5 lb. of Milk and Adjusted in 5-lb. Increments When the Production Curve Falls Outside the Limits for Three or More Consecutive Days.

Table 5. Standard Deviations and Coefficients of Variation Among Days Within Weeks, Months, Lactations and Cows for Milk Yield for Parities One and Two-or-More. (Shook, 1975)

Month of Lactation	Parity	Standard Deviations			Coefficients of Variation		
		A.M.	P.M.	daily	A.M.	P.M.	daily
1	1	2.1570	1.8265	3.1477	9.7976	9.7246	7.7152
1	2	2.9492	2.5767	4.3841	8.9697	9.2424	7.2154
2	1	1.4753	1.3766	2.0042	5.9832	6.6717	4.4253
2	2	2.3370	2.2890	3.2906	6.6070	7.7369	5.0658
3	1	1.4534	1.3130	1.9313	6.0926	6.6942	4.4429
3	2	2.3561	2.2392	3.1049	7.0892	8.1625	5.1178
4	1	1.4049	1.2855	1.9177	6.1987	6.9996	4.6740
4	2	2.2480	2.1041	2.9026	7.3364	8.3879	5.2086
5	1	1.3439	1.2026	1.8394	6.2606	6.9705	4.7507
5	2	2.1203	1.9032	2.7117	7.5484	8.3263	5.3226
6	1	1.2562	1.1775	1.7550	6.1693	7.2459	4.7933
6	2	1.9721	1.8379	2.5408	7.6458	8.7581	5.4316
7	1	1.2377	1.1129	1.6730	6.3970	7.2236	4.8139
7	2	1.8567	1.7486	2.4431	7.8843	9.1399	5.7242
8	1	1.2446	1.0600	1.6673	6.7472	7.2580	5.0447
8	2	1.8896	1.5562	2.4354	8.8230	8.9617	6.2798
9	1	1.1943	1.0592	1.6295	6.8324	7.6379	5.1981
9	2	1.6349	1.7910	2.5131	3.4742	11.4082	7.1818
10	1	1.1364	1.0875	1.5779	7.0012	3.4397	5.4193
10	2	1.5515	1.4595	2.0295	9.1109	10.5172	6.5667
11	1	1.1485	1.0283	1.5490	7.6976	8.6533	5.7792
11	2	1.5170	1.3883	2.0557	10.0679	11.2360	7.4959

milk production nor a constant percentage of the daily yield, but instead lies somewhere between. Hence, comparing daily yield to a fixed percentage of previous yields may make the comparison limit relatively too loose at the peak of the lactation curve or too tight near the end of lactation. Using a fixed increment rather than a percentage has the opposite effect. So it may be worth while to use a limit margin that is proportional to the standard deviation and accordingly adjusted periodically through the lactation period. Such a margin adjustment could be used either with running or periodic average methods, or with comparison to a regression curve.

Comparison to a Regression Curve

A third class of comparisons is that already alluded to--comparing the daily yield to an adjusted regression lactation curve. The regression model used for the 36 subclasses is the appropriate one to use because of the good fit (Wood, 1969; Schultz, 1974).

During early planning of this work, there was much discussion as to whether one could compare an individual cow to some sort of standardized curve at all, and if so, how one might adjust the curve to that cow's level of production. Several methods of adjustment were tried including adjusting to peak of production and adjusting to a specific day of the lactation. However, if the cow's curve did not have the same exact slope of the regression curve, she would eventually deviate from the curve enough to exceed tolerance limits, even if she were performing normally. It became apparent that the best approach was to make piecewise adjustments of the regression curve to the actual lactation curve. In that method, precise matching of the regression coefficients to a particular cow's curve became unnecessary, but the regression limit curve was still valuable.

Calculation of Regression-Based Limits

In establishing a method of calculating the adjusted or standardized regression curve limits, some initial arbitrary decisions were required concerning criteria for adjusting the limits, for limit margins, for initiation of these calculations, and for "flagging" the cow. Flagging in this context means giving an indication whenever the cow deviates beyond the comparison limit; i.e., whenever she is considered to have exceeded the tolerance for normal behavior. These initial decisions were (1) to initially adjust the regression limits at the seventh day of the lactation, (2) to establish both an upper and lower limit for the regression comparison limits, (3) to flag the cow whenever she dropped below the lower limit, (4) after day 7, to adjust both limits downward by a five-pound-of-milk step whenever the production remained below the limit for three consecutive days, and (5) to adjust both limits upward by one-pound increments for each day the cow was above the upper limit. These decisions were reached after making several trial plots with several limit-setting methods.

Evaluation of Comparison Methods

The relative value of each of the comparison methods was determined by applying each of them to the same yield and clinic code data set. Contingency table analysis was used to determine how each method classified the total number of lactation days in the data set. The summary contingency tables were classified as follows: the clinic data showed for each day that the cow was either sick or well (designated CSICK or CWELL, respectively); the analysis methods showed that the cow's milk production on each

day was either below or above the limit established by the comparison method (designated ASICK or AWELL, respectively). Thus, the two-way contingency table (see Table 6) contains four categories defined as follows: the true positives were those lactation days that were correctly shown to involve illness by the analysis method; the false positives were those lactation days that the analysis flagged as ill but for which the clinic showed no illness; the false negatives were ill lactation days not detected by the analysis; and the true negatives were healthy lactation days shown to be healthy by the analysis. The best analysis method would have the fewest false negatives, a number of true positives close to the total number of clinical ill lactation days, few false positives (though that number can be much larger than the false negatives), and the number of true negatives close to the number of healthy lactation days in the data.

More detailed contingency tables were also generated in which the CSICK category was subdivided into the six clinic code subclasses (010, 100, 200, 300, 400, 600, as discussed earlier), and the lactation was divided into four periods of 75 days each from day 7 to day 307 of the lactation. (See Appendix D for detailed tables.)

Table 6. Sample Summary Contingency Table

(Analysis Method 3011)

	CSICK	CWELL	TOTALS
	True Pos	False Pos	
ASICK	PERCENT 0.46	14.05	14.51
	OBSERVED 218.00	6687.00	6905.00
	EXPECTED 75.14	6829.86	
	DEVIATION 142.86	-142.86	
	CHISQ 271.63	2.99	
	False Neg	True Neg	
AWELL	PERCENT 0.63	84.86	85.49
	OBSERVED 300.00	40938.00	40698.00
	EXPECTED 442.86	40255.13	
	DEVIATION -142.86	142.86	
	CHISQ 46.09	0.51	
	TOTALS		
	PERCENT 1.09	98.91	100.00
	OBSERVED 518.00	47085.00	47603.00

CHAPTER V

RESULTS

Regression Analyses

The milk yield data from the 566 Beltsville lactations for Holsteins was divided into 36 subclasses of three parities, three age groups within parity, and four seasons of calving for the regression analyses. The resulting regression coefficients are somewhat similar to those calculated by Schultz (1974) for comparable pooled categories (see Table 4, Chapter 3). Note that the data used in this study included yields for every day of every lactation whereas Schultz used more lactations but only once-a-month test day data. The analyses of this study included approximately 200,000 records and were so powerful that the subsequent heterogeneity analysis (Table 3) showed statistically significant differences in the shape of the lactation curves for all the factors and interactions involved, even though one of the subclasses contained only one lactation. The greatest differences were among parities and the least were among ages within-parity and the age-by-season within parity interaction.

Contingency Analyses

Table 7 summarizes the results of contingency analyses for 25 methods of comparison and Table 8 lists the method code numbers and their explanation. The 1100 numbers are for three-day averages, the 1200 for seven-day

Table 7. Summary Results of 25 Contingency Analyses in Percent.

Method Code	True Positive	False Pos	False Negative	True Neg	ill (CSICK)	flagged (ASICK)	ill detected*
1111.	0.27	2.70	0.82	96.22	1.09	2.97	24.8
1112.	0.51	2.45	0.82	96.22	1.33	2.97	38.3
1121.	0.39	10.64	0.69	88.27	1.09	11.04	35.8
1122.	1.11	9.93	0.69	88.27	1.81	11.04	61.3
1132.	0.51	1.93	0.83	96.74	1.33	2.44	38.3
1211.	0.35	4.11	0.74	94.80	1.09	4.46	32.1
1212.	0.71	3.75	0.74	94.80	1.45	4.46	49.0
1221.	0.47	13.93	0.62	84.98	1.09	14.40	43.1
1222.	1.40	13.00	0.62	84.98	2.02	14.40	69.3
1232.	0.68	2.83	0.74	95.75	1.42	3.51	47.9
2011.	0.42	7.25	0.67	91.67	1.09	7.66	38.5
2012.	0.94	6.72	0.67	91.67	1.61	7.66	58.4
2021.	0.23	1.22	0.86	97.69	1.09	1.45	21.1
2022.	0.35	1.10	0.86	97.69	1.21	1.45	28.9
2031.	0.55	20.21	0.54	78.70	1.09	20.76	50.4
2032.	1.77	18.99	0.54	78.70	2.31	20.76	76.6
2042.	0.95	5.30	0.68	93.08	1.63	6.25	58.3
3011.	0.46	14.05	0.63	84.86	1.09	14.51	42.2
3012.	1.35	13.16	0.63	84.86	1.98	14.51	68.2
3021.	0.38	5.46	0.71	93.46	1.09	5.83	34.9
3022.	0.85	4.98	0.71	93.46	1.56	5.83	54.5
3411.	0.45	14.08	0.64	84.83	1.09	14.53	41.3
3412.	1.38	13.15	0.64	84.83	2.01	14.53	68.7
3421.	0.38	5.22	0.70	93.69	1.09	5.60	34.9
3422.	0.87	4.73	0.70	93.69	1.57	5.60	55.4

*True positive ÷ CSICK.

Table 8. Key to Analysis Method Codes.

1111.	Running average, 3 days, 90% limits, day-to-day.
1112.	Running average, 3 days, 90% limits, 6-day predictive.
1121.	Running average, 3 days, 1 standard deviation, day-to-day.
1122.	Running average, 3 days, 1 standard deviation, 6-day predictive.
1132.	Running average, 3 days, 2 standard deviations, 6-day predictive.
1211.	Running average, 7 days, 90% limits, day-to-day.
1212.	Running average, 7 days, 90% limits, 6-day predictive.
1221.	Running average, 7 days, 1 standard deviation, day-to-day.
1222.	Running average, 7 days, 1 standard deviation, 6-day predictive.
1232.	Running average, 7 days, 2 standard deviations, 6-day predictive.
2011.	7-day updated average, 90% limits, day-to-day.
2012.	7-day updated average, 90% limits, 6-day prediction.
2021.	7-day updated average, 80% limits, day-to-day.
2022.	7-day updated average, 80% limits, 6-day predictive.
2031.	7-day updated average, 1 standard deviation, day-to-day.
2032.	7-day updated average, 1 standard deviation, 6-day predictive.
2042.	7-day updated average, 2 standard deviations, 6-day predictive.
3011.	36-subclass regression, 1 standard deviation, day-to-day.
3012.	36-subclass regression, 1 standard deviation, 6-day predictive.
3021.	36-subclass regression, 2 standard deviations, day-to-day.
3022.	36-subclass regression, 2 standard deviations, 6-day predictive.
3411.	3-subclass regression, 1 standard deviation, day-to-day.
3412.	3-subclass regression, 1 standard deviation, 6-day predictive.
3421.	3-subclass regression, 2 standard deviations, day-to-day.
3422.	3-subclass regression, 2 standard deviations, 6-day predictive.

running averages, the 2000 series of numbers are for seven-day periodically-updated averages which are methods similar to those used in Great Britain (Price, 1975). The 3000 series of numbers are for regression curve comparisons. The sixth and seventh columns of Table 7 show, respectively, the percentage of total lactation days that were ill or potentially ill, and the percentage of total lactation days flagged by each analysis method. The "ill detected" column shows the percentage of ill lactation days actually detected by the analysis method. It was desirable to minimize the number of flags and maximize the number of illnesses detected.

As can be seen in the "ill detected" column, in no case were all the ill lactation days detected. The maximum detected was 76.6 percent by comparing to a seven-day, periodically-updated average diminished by 1.0 standard deviation (method 2032). However, over 20 percent of the lactation days were flagged by that method, meaning that the dairy manager would have to examine 20 percent of the cows to find 3/4ths of the 2.31 percent that were ill or potentially ill. He would need some other method to find the other 1/4th of the ill or potentially ill cows. The two methods that detected over 68 percent of the ill or potentially ill cow days and flagged less than 15 percent of the total lactation days were those methods that compared the daily yield to adjusted regression curve limits with the limits being ±1.0 standard deviation from the lactation curve (methods 3012 and 3412). Note that method 3412 uses only three different regression curves (parities 1, 2, or 3) and did a slightly better job than method 3012 which used the 36 subclass regression curves. Hence the answer to the question raised earlier as to whether there were practical differences among all three factors of parity, age within parity, and season of

calving in this application is no. It is possible, too, that only two regression curves, one each for parities 1 and 2, are needed because of the similarity of shapes of curves for parities 2 and 3 or more (Shook, 1974). (See also Figure 2.)

A method that detected slightly more of the ill lactation days (69.3 percent) with slightly fewer flags (14.4 percent) was that of a seven-day running average with 1.0-standard-deviation limits (method 1222). Note that the methods using 1.0-standard-deviation limits in the six-day predictive mode (methods 1222, 2032, 3012, 3412) did a better job of detecting ill lactation days than the other methods, but resulted in more flagging. Also, with limits set that tight, there was little real difference among these methods; in particular the regression curves were readjusted so frequently that much of the value of the regression was lost.

With limits set more loosely, the picture changes somewhat. Method 2912, 90 percent limits on a seven-day periodically-updated average, which is the present method used by Price in Great Britain (Price, 1975), flagged 7.66 percent of the lactation days and detected 58.4 percent of the ill ones. The 36-regression method with limits of ± 2.0 standard deviations (method 3022) flagged only 5.83 percent and detected 54.5 percent of the ill lactation days. (This means that with this method the dairy manager must examine roughly six percent of his cows per day to find half of the 1.56 percent that need his attention. He must use other means to find the remainder of the cows needing special attention.) The three-regression method with limits of ± 2.0 standard deviations (method 3422) flagged only 5.6 percent and detected 55.4 percent of the

problems. The seven-day updated average method with 2.0-standard-deviation limits (method 2042) detected 58.3 percent of the problems while flagging 6.25 percent of the herd. Note that this method detected approximately the same number of problems as method 2012 but flagged fewer cows. This result demonstrates that the standard-deviation limits are slightly more efficient than the percentage limits. Comparison of methods 1112 and 1132, and of methods 1212 and 1232 show the same result.

Of the major groups of methods tried, the three-day running average was the least successful of the three and the ranking between the seven-day running average and the seven-day periodically-updated average was rather close. The ranking of the regression methods was on par with both of the seven-day methods.

Figures 10, 11, 12, and 13 show plots of the lactation curve for the same cow along with limits generated. In Figure 10, limits are the regression curve ± 1.0 standard deviation (method 3012); in Figure 11, the limits are the average of the previous week's yield less 1.0 standard deviation (method 2032); in Figure 12, limits are 80 percent of the previous week's yield average (method 2022); and in Figure 13, the limits are the seven-day running yield average less 1.0 standard deviation (method 1222). The clinic diagnoses for that cow in the lactation were, in chronological order, foot rot, pyometra, mastitis, mastitis, mastitis, scours, mastitis, foot problem, rectal exam, and foot rot. Each of those exams is represented by one of the 10 spikes on the clinic flag line near the bottom of the graph. The analysis flags are represented by the spikes at the very bottom of the graph. One can see that the limits are rather tight for all but Figure 12.

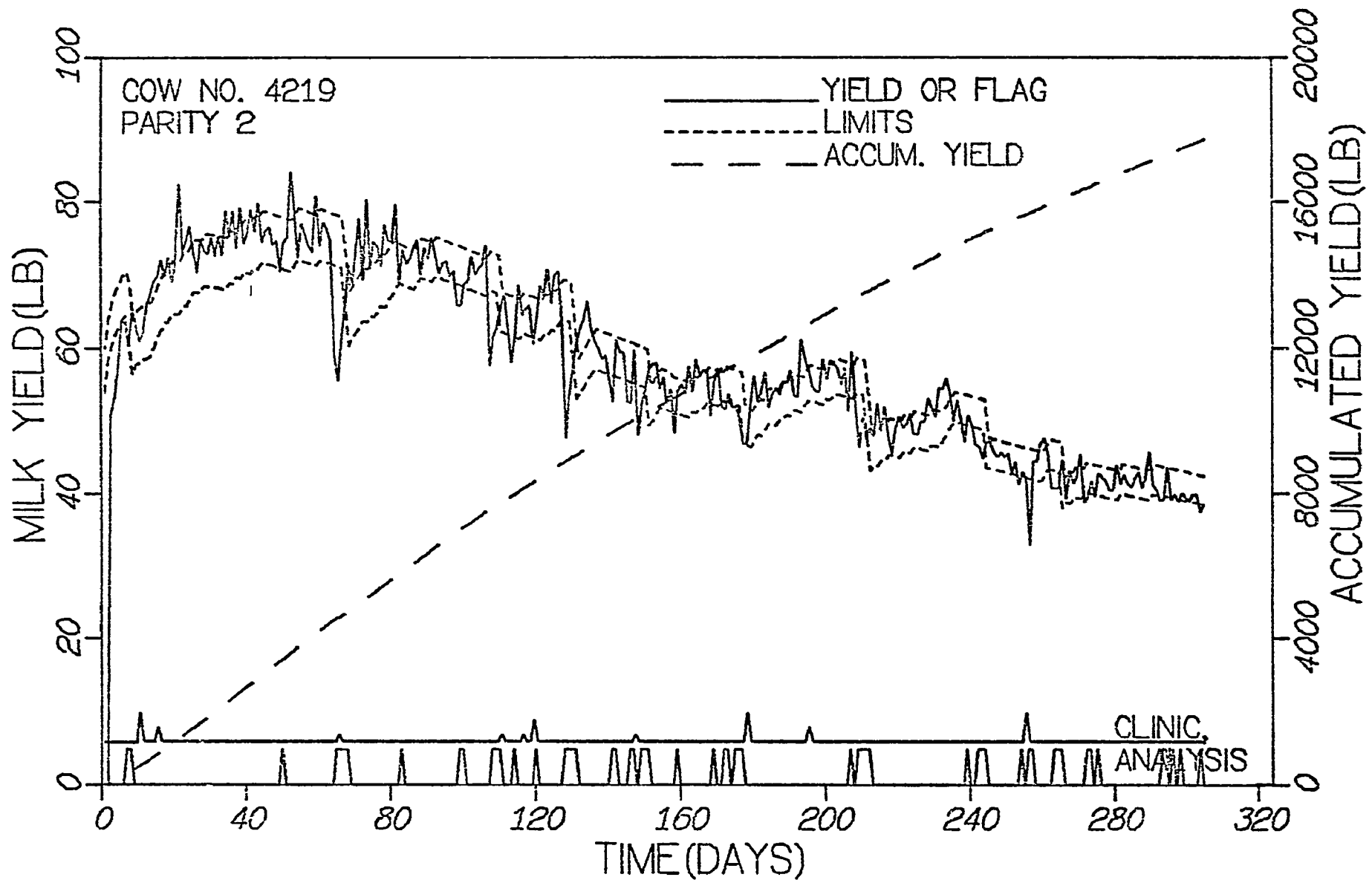


Figure 10. Lactation Curve with Limits Equal to Regression Curve ± 1.0 Standard Deviation (Method 3012).

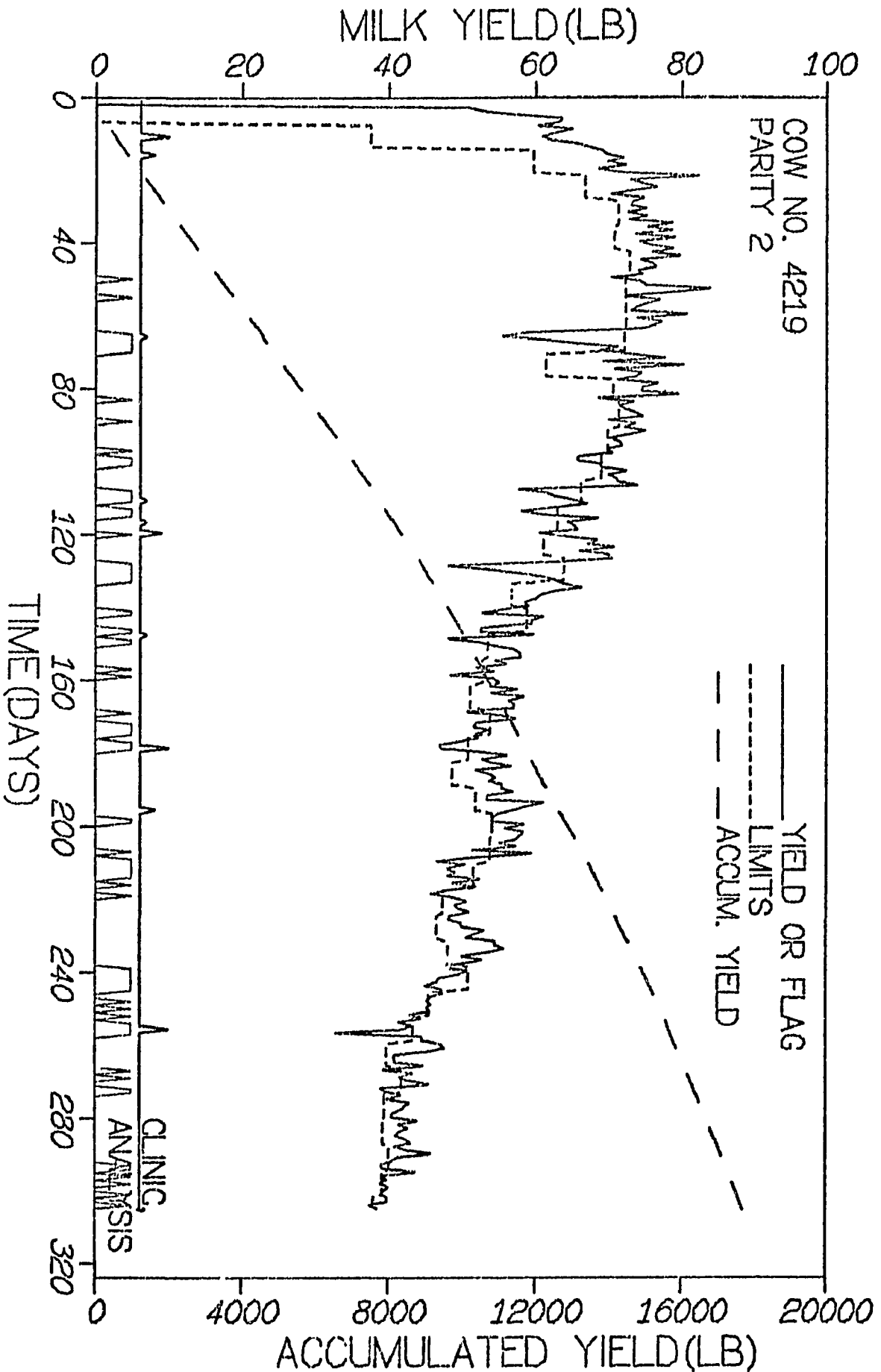


Figure 11. Lactation Curve with Limit Equal to the Average of the Previous Week's Daily Yield Less 1.0 Standard Deviation (Method 2032).

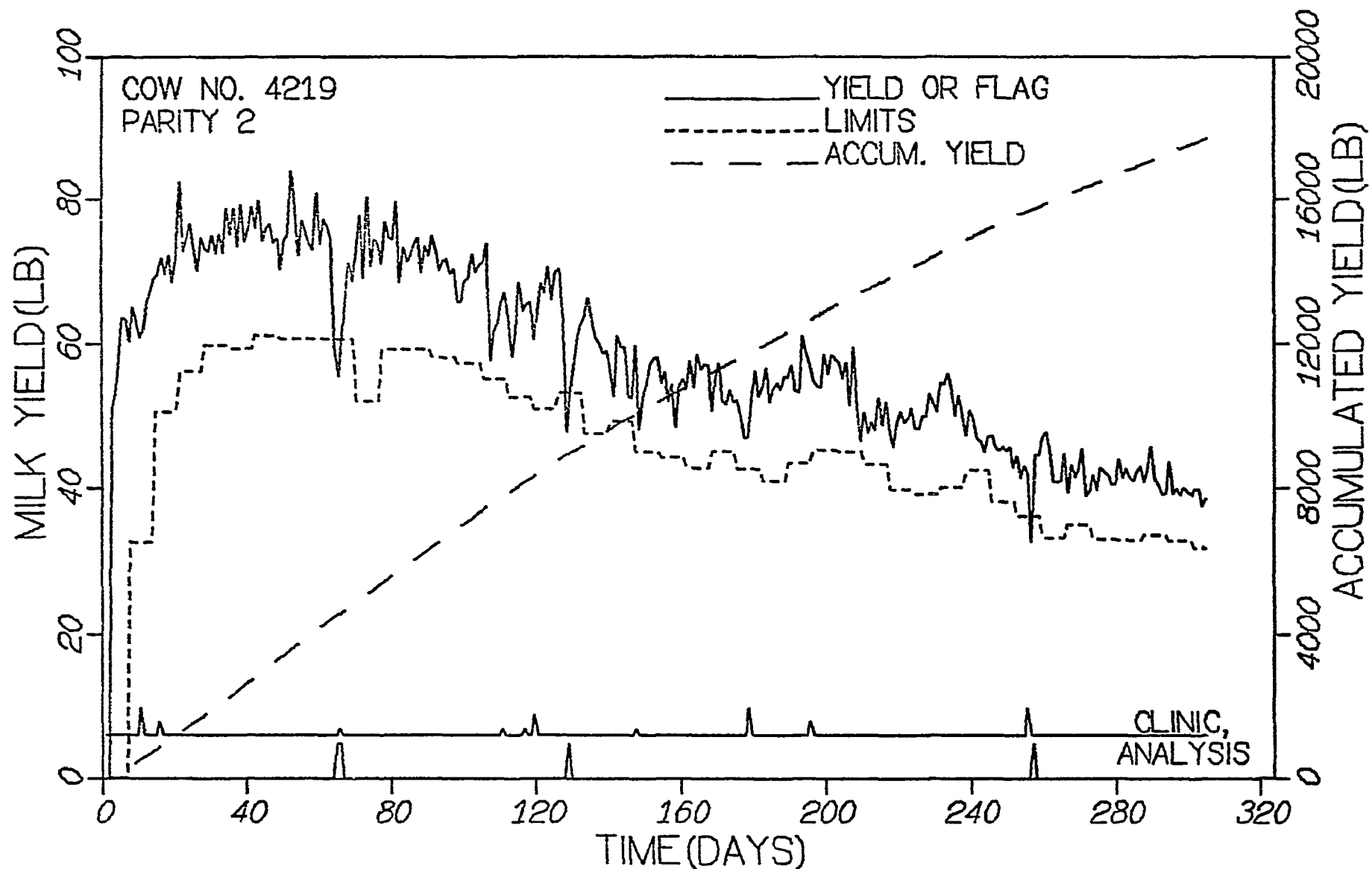


Figure 12. Lactation Curve with Limit Equal to 80 Percent of the Previous Week's Daily Yield Average (Method 2022).

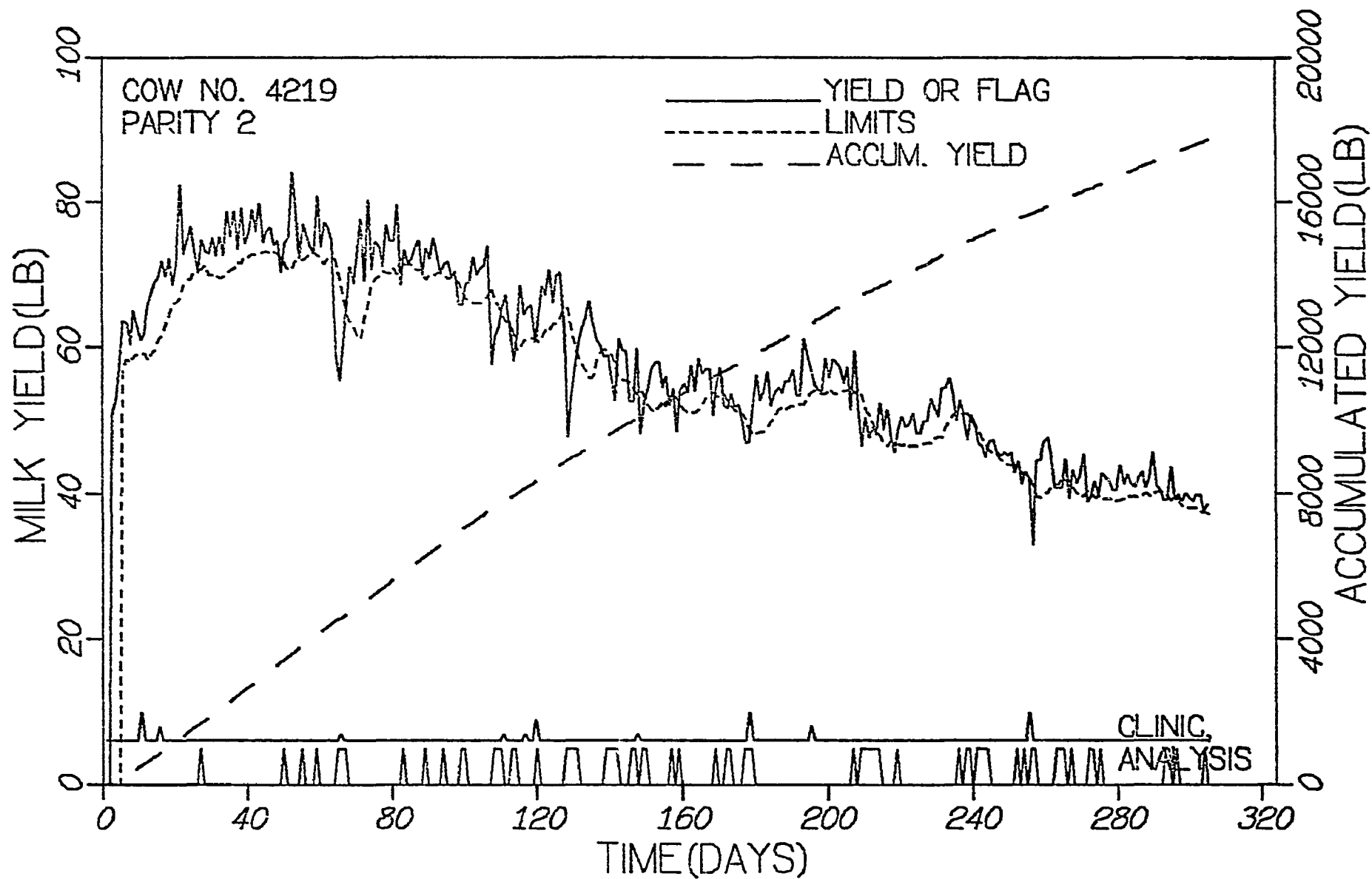


Figure 13. Lactation Curve with Limit Equal to the 7-day Running Daily Yield Average Less 1.0 Standard Deviation (Method 1222).

The detailed contingency tables generated in addition to the summary tables are contained in Appendix D. They show in general that the majority of the ill lactation days were due to problems in health code categories 100, 200, and 300. No easily seen patterns appeared among the four time periods into which the lactation was divided in those tables.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

The Validity of Management by Exception

One of the questions asked all through this study was whether the concept of management by exception was a valid one. The results show that over 50 percent of the problem cows each day can be detected by monitoring milk yield alone. The method of comparing to a standardized regression curve with limits of ± 2 standard deviations allows the dairy manager to find half the problems by examining less than six percent of his total herd. Therefore, the answer to the question as to the validity of management by exception is yes, it is valid, and it is valuable.

The results of this work are, if anything, conservatively biased regarding the value of the concept for two reasons. The first reason is the somewhat arbitrary basis on which it was decided whether each cow was, on a specific day, ill or well. Using the clinic records or the clinic records within-six-days as a basis for deciding cow condition is not precise because the dairyman may not have noticed a problem and the veterinarian may not have been called. Such problems, if they affected milk yield, would result in the flagging of cows that were not recorded as ill in the clinic records and hence would give a higher number of false positive indications. The second reason for this conservative bias of the

results is that illnesses which may not have affected milk production were recorded in the clinic records. These illnesses would not be detected by the analysis and thus would result in larger numbers in the false negative category than would otherwise have occurred. Foot rot is a good example of such an illness. Figure 14 shows cow 4072 in parity 2. All her clinic records for that lactation were foot rot problems except for the first two which were for ovarian cysts. The figure shows no apparent relationship between milk yield and the foot rot occurrences. Approximately 12.5 percent of the clinic records in the data were for anatomical problems including foot rot, and approximately 42 percent of those were detected by method 3022, whereas that method detected 54 percent of the overall health problems. Thus, while the data used resulted in biases against the concept of management by exception, the concept proved its worth in spite of those biases. Indeed, with the contingency methods used, none of the biases applied to the data made the results appear better than they would without bias; rather the biases made the results appear less desirable.

The More Useful Methods of Comparison

In Table 7, the pertinent methods to examine were those that used the six-day predictive mode (those with numbers ending in "2") because the purpose was to predict or anticipate health problems. Table 9 is a selection from Table 7 of all the six-day predictive methods that used limit margins of 1.0 and 2.0 standard deviations. It has already been pointed out (Chapter 5) that standard-deviation limits are slightly more efficient than percentage limits. Table 9 shows that the flagging rate varies widely

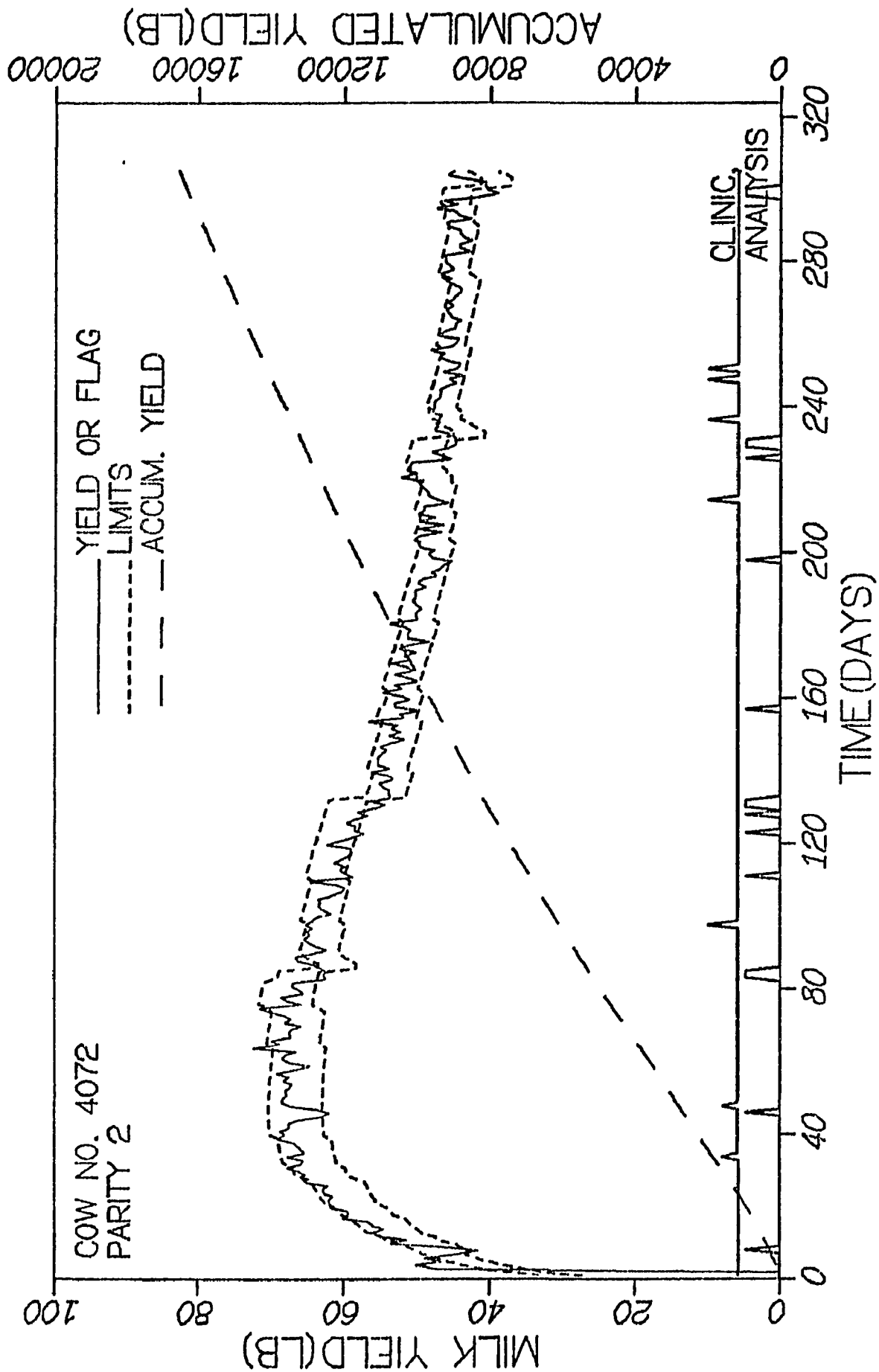


Figure 14. Lactation Curve for Cow with Foot Rot Problems (Method 3012).

Table 9. Selected Analysis Methods

Limit width in standard deviations	Method* code	Description	Percent flagged	Percent of ill detected
1	1122	3-day running average	11.04	61.3
1	1222	7-day running average	14.40	69.3
1	2032	7-day updated average	20.76	76.6
1	3012	36-subclass regression	14.51	68.2
1	3412	3-subclass regression	14.53	68.7
2	1132	3-day running average	2.44	38.3
2	1232	7-day running average	3.51	47.9
2	2042	7-day update average	6.25	58.3
2	3022	36-subclass regression	5.33	54.5
2	3422	3-subclass regression	5.60	55.4

*All these methods are in the six-day predicted mode.

with the analysis method even when the same limit margins are used. The methods using 1.0-standard-deviation limits varied in flagging rate from 11 to 20 percent; those using 2.0 standard deviations varied from 2.44 to 6.25 percent. It is apparent that the three-day running average method can be used with tighter limits than can a longer (e.g., seven-day) running average method.

If one sets a goal of detecting 50 to 60 percent of the health problem, it appears that the three-day running average method is the least efficient of the methods because at a detection rate of 61.3 percent it flags 11 percent of the herd while other methods detecting 55 to 58 percent

of the problems flag only 5.6 to 6.25 percent of the herd. Therefore, one can conclude that the three-day running average method may be eliminated from further investigation.

The results in Table 9 are not definitive on the relative values of the other methods. The seven-day running average, seven-day updated average, and regression methods all gave similar results. It is apparent, however, for the methods using 2.0-standard-deviation limits, that between 50 and 60 percent of the health problems can be detected with flagging rates of between 5.5 and 7 percent of the herd.

The results are not definitive on the relative values of the methods in detecting acute versus chronic problems. However, the nature of the regression and seven-day updated average methods leads one to conclude that they would be more efficient at detecting the slowly varying chronic problem than would the seven-day running average method, because the latter will tend to follow rather than detect these changes as compared to the other methods.

Regression Analysis

The regression analysis by 36 subclasses was powerful enough to show statistically-significant heterogeneities of the regression coefficients for all the factors and interactions involved. However, comparison of the contingency analysis results in Table 7 for methods 3412 and 3012 (comparison to one of three regression curves and to one of 36 regression curves, respectively) shows that use of regression curves for parities 1, 2, or 3 may be sufficient and it may not be necessary to classify the cow by age and/or season of calving when comparing a cow's milk yield performance to the regression curve.

CHAPTER VII

RECOMMENDATIONS FOR FURTHER WORK

Limitations of This Study

This work of necessity included a broad survey of methods of comparison because there was little or no precedent for this approach. Hence the study could not encompass any of the possible methods in great detail. The primary goal was to develop a basis for implementation of the concept of management by exception. That goal included testing the validity of the concept and exploring possible ways of using it if it proved valid. The work proved that the concept was valid and demonstrated several workable methods for applying it to dairy cow milk yields.

Milk Yield Methods to Explore Further

The most promising methods of comparison, i.e., those that detected the greatest percentage of ill lactation days while flagging the least number of cows, are those using seven-day running or periodically-updated averages, and those using comparison to regression curve limits. It is difficult to know at this point what criteria should be used for percentage of herd flagged versus percentage of health problems detected. However, it appears reasonable, given the knowledge gained so far, that flagging from 5 to 10 percent of the herd is acceptable. This range would provide a

corresponding multiplication of the dairy manager's capacity to monitor health problems in a given amount of time of potentially more than 10 times his present capability. One could next test the seven-day running average, seven-day updated average, and three-regression curve comparison methods with several increments of percentage margin limits and standard-deviation limits until flagging rates of approximately five and approximately 10 percent for each of the methods were achieved. Then one could examine the resulting illness detection rates. These tests could be run using the same Beltsville data set. Such tests would help pinpoint the best methods to use at these flagging rates.

The next tests might then be run on A.M. and P.M. yields separately to see if such analysis would give significantly better results than once-a-day analysis. Again, these tests too could be run with the Beltsville data set.

Yet another possibility is to use multiple criteria for comparison as follows: A relatively loose limit that causes flagging any time milk production drops below it; a second limit set more tightly that causes flagging if yield drops below it for two or three consecutive days; and a third, still tighter limit that causes flagging if yield drops below it for six or seven consecutive days. Criteria for the readjustment of such limits and their relative spacing would also have to be developed. These tests too could be run first on the Beltsville data set so that a fair comparison among methods would be achieved. The multiple criteria method may help to pick up gradual abnormal declines, particularly with running average type methods. However, the regression comparison methods already have that capability to some extent if the regression curve is properly

matched to the cow's normal lactation curve. If it is properly matched, she will eventually be flagged if she begins any abnormally steep rate of decline in production.

Note that it is important to run all these tests on the same data set to get a true picture of their relative merits unless one wishes to use multiple data sets and then run statistical analyses to test differences among the methods. This latter approach is really not necessary to get relative merits.

New Data Set

It has been suggested that a new data set be acquired to test the foregoing methods in order to get a better idea of their value in a normal dairy situation. To provide the best test of the concept of management by exception, the data should meet the following criteria:

- (1) The twice-daily milk yield records should be as accurate and as complete as humanly possible, seven days a week.
- (2) The data must be from a significant number of cows from each of several parities and all of the same breed--possibly 60 to 100 or more animals.
- (3) Daily comments must be recorded by the herdsman and/or veterinarian as to the health of each animal in the test. A check sheet asking whether the cow has a health problem and if so, what problem, is a must, seven days a week.
- (4) The data must be for a significant part of each animal's lactation, preferably the entire lactation.

- (5) If possible daily analysis by one or more of the methods tested in the foregoing study should be made to keep a running check on the data acquisition and to learn more about the use of such methods in a real dairy situation.

Next Steps in Implementing Management by Exception

It is apparent that to acquire the data set with the criteria put forth in the last section will require a large amount of conscientious manpower if it is to be done manually. Thus, a parallel development of automatic equipment is needed to help implement management by exception. Automatic milk yield measuring and recording is needed, as is automatic determination and recording of the identity of each animal. Therefore, it appears that the implementation should proceed along at least two parallel paths from this point forward; one path to further develop and refine methods of performance analysis; and a second path to develop the hardware needed to implement the analysis techniques on a practical basis.

Other Approaches Not Yet Tested

A possible third avenue of study to parallel the two mentioned in the previous section is that of monitoring and analyzing milk conductivity in addition to analyzing milk yield. An earlier study (Greatrix, et al., 1968) found that "The results suggest that relative conductivity can be used to detect three out of every four cows yielding milk samples from one or more quarters with a [leucocyte] cellular content greater than 500,000/ml, and about four out of every five cows with a cellular content greater than 1,000,000/ml. Less than one in 20 cows would be

incorrectly detected as having cell counts greater than 500,000/ml in milk from any one quarter." Hence, the addition of conductivity monitoring to milk yield monitoring would detect potentially many more than 50 percent of the problem cows.

A fourth parallel avenue of study is to monitor cow body temperature (or milk temperature as an indication of body temperature) to detect problem cows (exceptions). The potential value of a system that automatically monitors milk yield, milk conductivity, and milk temperature in the milking parlor, analyzes these data during the milking operation, and gives the dairy manager immediate results is very great indeed. With present technology, such a system is well within reach.

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APPENDIX A

LACTATION CURVE EQUATIONS

The final equation used in the regression analysis in this work was

$$y = t^b e^{(a-ct)} \quad (A1)$$

where y = daily milk yield in lb.

t = time in days

b = constant

a = constant

c = constant

e = base of Napierian logarithms.

This equation is of the same general form as those used by Schultz (1974) and Wood (1967). It was used because it fits the lactation curve well and because it can be easily fitted using multiple linear regression when it is transformed to the logarithmic form

$$\ln y = a + b \ln t - ct . \quad (A2)$$

The peak day of the lactation curve may be determined by differentiating equation (A1) above and setting it to zero as follows:

$$\frac{dy}{dt} = t^b e^{(a-ct)} (-c) + e^{(a-ct)} b t^{b-1} = 0$$

$$0 = e^{(a-ct)} (b t^{b-1} - ct^b)$$

$$\therefore ct^b = b t^{b-1}$$

or $c = b t^{-1}$

then $t = b/c$.

A second-order exponential equation of the form $Y = A e^{-r_1 t} + B e^{-r_2 t}$ might also be used to describe the lactation curve. Note that the equations published by Brody (1945) were of a similar form. This equation is the difference between a slowly decreasing exponential decay (the $A e^{-r_1 t}$ term) and a more rapidly decreasing exponential decay ($B e^{-r_2 t}$). If one can assume an average rate of decline of milk production after the peak of the lactation curve, that rate of decline is approximately equal to r_1 . If the time of peak production and the initial production as a percentage of peak production can be estimated, then the constants A and B may be determined. Then an iterative procedure such as the Newton-Raphson technique (Stoecker, 1971) may be used to calculate r_2 . Using T as time in weeks, assuming a rate of decline of 2% per week, a peak at the sixth week of production, and initial production equal to 75% of the peak production, yields the following equation:

$$Y = 1.203 e^{-0.02T} - 0.453 e^{-.318T}, \quad (A3)$$

where Y is the percentage of peak yield, which is representative of an over-damped, second-order system. However, this equation is really of only academic interest in this study because the equation form used by Wood and Schultz is much easier to fit to the data.

APPENDIX B

DATA MANIPULATION PROGRAMMING

Table B1 lists card image information for the taped Beltsville lactation data. It was necessary to convert these data to a form in which the day of the lactation was available explicitly. The program written for that purpose was also used in conjunction with other routines such as matching each cow to a parity index or a parity, season, age-group index; hence, blocks for such work are also included. Figure B1 is the flow diagram for the program, and listing B1 is the actual program. Listing statements beginning with "CC" are optional routines.

Figure B2 is the flow diagram for the program to collate clinic code records with yield records for the data set used for the contingency analyses. Listing B2 is the actual program.

Table B1. Card image information.

Columns	Information
1,2	herd number
3	breed code
4-7	cow ID number
8	parity
9-14	calving month-day-year
15-18	data month-year
19-20	milking interval code
21-23	age at calving in months
24	card number (for the month, 4 cards per month)
25-72	three-digit A.M. and P.M. milk yields for 8 days in sequence, e.g. columns 25-30 are A.M. and P.M. yield for day 1 of the month on card 1, day 9 on card 2, day 17 on card 3, day 25 on card 4 for any given month. The milk weights are recorded to 1/10 lb. and the decimal is omitted from the tape.

Figure B1. Flow Diagram for Program to Convert to Day of Lactation.

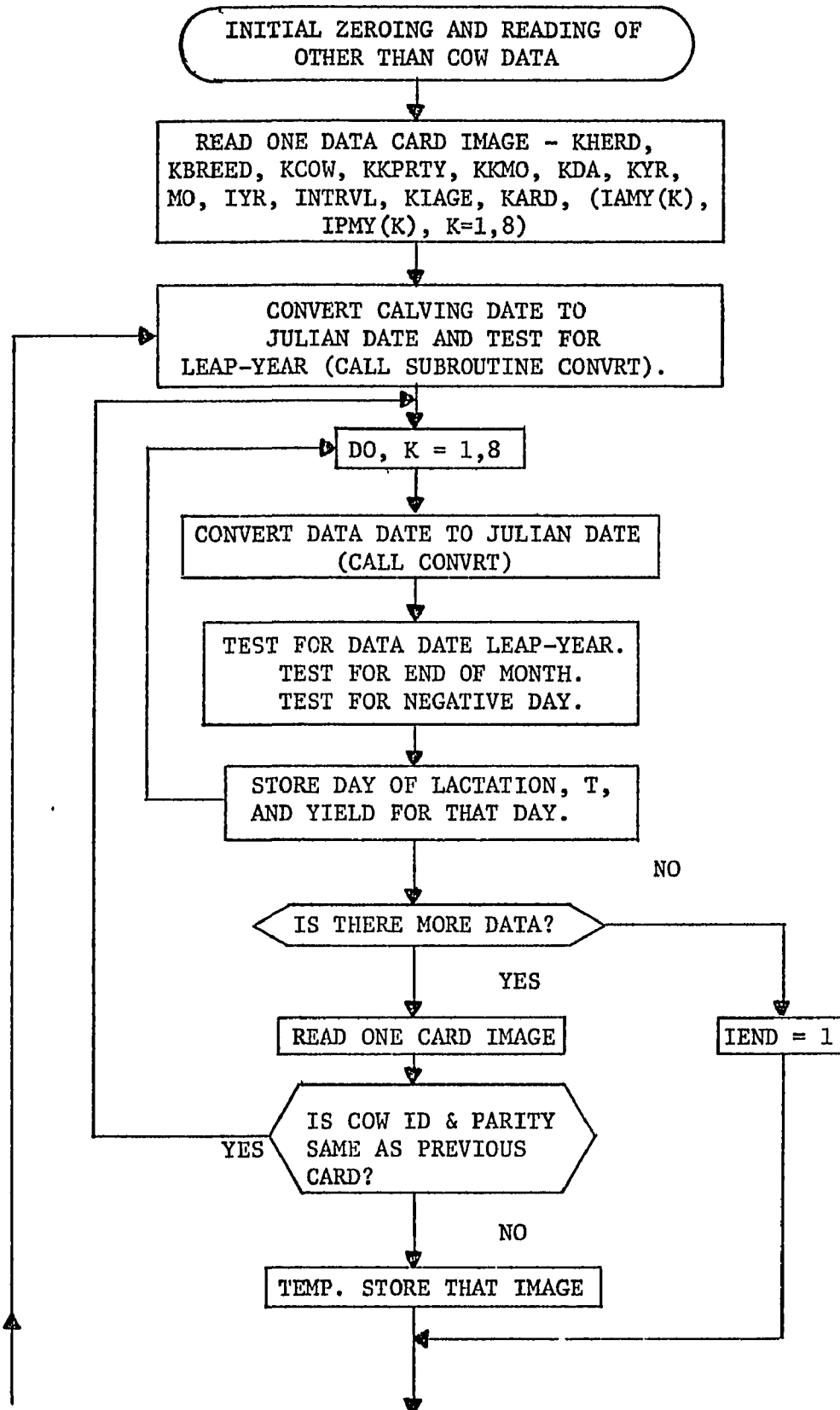
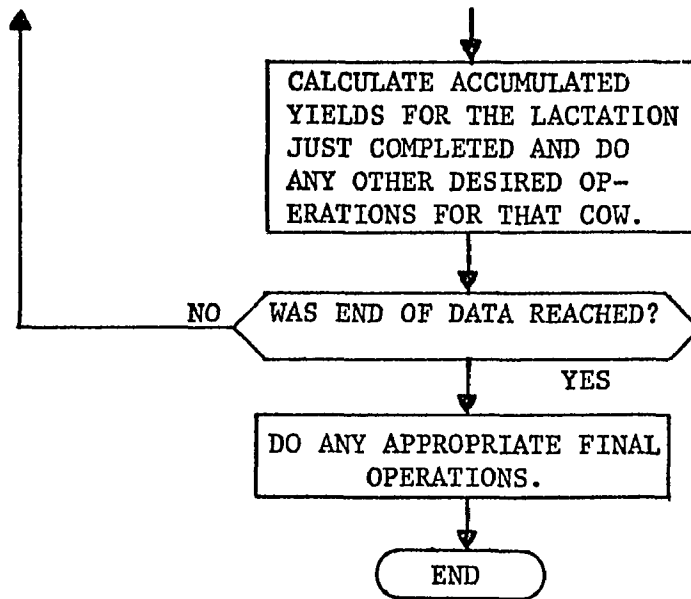


Figure B1 (continued)



```

C
C
C
C LISTING 81.  CONVERSION TO DAY OF LACTATION.
C REGION=104K,TIME=22 M'N.,IOREQ=5000,COST=$33.67.
// EXEC FORTLDGO,REGION=104K
//FORT.SYSIN DD *
C
C
C FORTRAN PROGRAM FOR CONVERTING BELTSVILLE TAPED COW DATA TO DAY OF
C LACATATION AND WRITING ON TAPE OR DISC.  EACH RECORD IS 35 COLUMNS
C LONG AND CONTAINS HERD, BREED, COW NO., PARITY, CALVING DATE,
C INTERVAL, AGE, DAY, AM AND PM YIELDS (WITH DECIMAL POINTS), TOTAL
C OBERSERVATIONS FOR THAT COW, AND 2 BLANK COLUMNS.
C LRECL=35, BLOCK SIZE=35*114=3990.
C
C
C      DIMENSION IAMY(8),IPMY(8),T(325),YAM(325),YPM(325)
CC      1YLD(325),ALIM(325),      FLAG(325),ACCYLD(325),SCX(2),SCY(2),
CC      2PQY(2),VFLAG(325),COW(2),
CC      3 DNLIM(325), UPLIM(325)
CC      REAL INDEX(36)/36*0.0/,A(36)/36*0.0/,B(36)/36*0.0/,C(36)/36*0.0/
C
C      INTEGER T, HERD, BREED, CMONTH, CDAY, CYEAR, AGE, PARITY
C INITIAL ZEROING AND READING OF OTHER THAN COW DATA.
C
C      REWIND 3
C      REWIND 4
C      NN=0
C      IEND=0
CC      DO 110 I=1,3
CC      READ(5,100) INDEX(I), A(I), B(I), C(I)
CC      NN=NN+1
CC100 FORMAT(23X,I3,T31,3F5.3)
CC110 CONTINUE
CC      WRITE(6,120)(INDEX(I),A(I),B(I),C(I),I=1,NN)
CC120 FORMAT(' ','INDEX,A,B,&C,RESPECTIVELY,= '/(15,3F10.3))
C      DO 800 J=1,325
CC      YLD(J)=0.
C      T(J)=0.
C      YAM(J)=0.
C      YPM(J)=0.
CC      ACCYLD(J)=0.
CC      DNLIM(J)=0.
CC      UPLIM(J)=0.
C      800 CONTINUE
CC      CALL PLOT(1.0,1.0,-3)
C
C END OF INITIATION PROCEDURES.
C
C BEGIN READING & STORING COW DATA.
C
C READ HERD, BREED, COW NO., PARITY, CALVING DATE, DATA MO. & YR., DAYTIME
C MILKING INTERVAL CODE, AGE(MONTHS)AT CALVING, CARD NO., AND 8 DAYS OF
C AM & PM YIELD DATA.
C      990 READ(3,1000,ERR=6000,END=1905)KHERD,KBREED,KCOW,KKPRTY,KKMO,KDA,
C      1KYR,MO,IYR,INTRVL,KIAGE,KARD,(IAMY(K),IPMY(K),K=1,8)
C      1000 FORMAT(I2,I1,I4,I1,6I2,I3,I1,16I3)
C      1010 J=0
C      HERD=KHERD
C      BREED=KBREED

```

```

      KOW=KCOH
      PARITY=KKPRTY
      CMONTH=KKMO
      CDAY=KDA
      CYEAR=KYR
      INT=INTRVL
      AGE=KIAGE
      KPRTY=KKPRTY
      KMO=KKMO
      IAGE=KIAGE
C   CALCULATE DAY OF LACTATION.
C   CONVERT CALVING DATE TO JULIAN DATE & MAKE LEAP YEAR DETERMINATION.
      CALL CONVRT(KMO,KDA,KYR,JCDATE,JFEB)
      IF(JFEB.EQ.29)GO TO 1100
      LEAP=0
      GO TO 1250
1100 LEAP=JCDATE
1250 CONTINUE
      DO 1900 K=1,8
      IDAY=K+8*(KARD-1)
C   CONVERT TO JULIAN DATE.
      CALL CONVRT(MO,IDAY,IYR,JDATE,JFEB)
      MOEND=31
      IF(JFEB.EQ.29) GO TO 1255
      IF(MO.EQ.02) MOEND=28
      GO TO 1256
1255 IF(MO.EQ.02) MOEND=29
1256 IF(MO.EQ.04) MOEND=30
      IF(MO.EQ.06) MOEND=30
      IF(MO.EQ.09) MOEND=30
      IF(MO.EQ.11) MOEND=30
      IF(IDAY.GT.MOEND) GO TO 1900
      JDIFF=JDATE-JCDATE
      IF (JDIFF.LE.0)GO TO 1900
      IF(JDIFF.LT.600)GO TO 1300
      IF(LEAP.NE.0)GO TO 1260
      JDIFF=JDIFF-1
1260 JDIFF=JDIFF-634
      IF(J.GE.322) GO TO 1900
1300 J=J+1
      T(J)=JDIFF
C   STORE YIELD DATA IN ARRAYS.
      YAM(J)=IAMY(K)
      YAM(J)=YAM(J)/10.
      YPM(J)=IPMY(K)
      YPM(J)=YPM(J)/10.
CC   YLD(J)=YAM(J)+YPM(J)
C   END OF LOOP FOR PROCESSING ONE CARD.
1900 CONTINUE
C
C
C   NEXT READ ONE MORE CARD & TEST WHETHER COW NUMBER & PARITY ARE SAME.
      READ(3,1000,ERR=6000,END=1905)KHERD,KBREED,KCOH,KKPRTY,KKMO,KDA,
      1KYR,MO,IYR,INTRVL,KIAGE,KARD,(IAMY(K),IPMY(K),K=1,8)
      GO TO 1906
1905 IEND=1
      GO TO 1910
1906 IF(KKPRTY.NE.KPRTY)GO TO 1910
      IF(KCOH.NE.KOW)GO TO 1910
      GO TO 1250
C

```

```

C  END OF LOOP FOR READING ONE COW'S DATA.
C
C
C  BEGIN CALCULATIONS FOR ONE COW.
C
  1910 CONTINUE
      N=J
CC  ACCYLD(1)=YLD(1)
CC  DO 1940 J=2,N
CC  ACCYLD(J)=ACCYLD(J-1)+YLD(J)
  1940 CONTINUE
C
CC  DO 1941 J=1,325
CC  FLAG(J)=0.
  1941 CONTINUE
C
C  CALCULATION & OUTPUT SEGMENTS FOR INDIVIDUAL COWS.
      DO 1955 J=1,N
          WRITE(4,1948) HERD,BREED,KOW,PARITY,CMONTH,CDAY,CYEAR,INT,AGE,
            1T(J), YAM(J), YPM(J),N
          1948 FORMAT(12,11,14,11,4I2,2I3,2F4.1,13)
          1955 CONTINUE
C  END OF CALCULATIONS FOR ONE COW.
C
C
C  IF ALL COWS ARE DONE, DO FINAL CALCULATIONS; OTHERWISE PREPARE TO
C  READ NEXT COW.
C  COW.
      IF(IEND.EQ.1) GO TO 1980
C  INCREMENT PLOT TO NEW SET OF COORDINATES.
CC  CALL PLOT(10.0,0.0,-3)
      GO TO 1010
  1980 CONTINUE
C
C  FINAL CALCULATIONS.
      ENDFILE 4
      REWIND 4
      WRITE(6,1945)
  1945 FORMAT(' ',HERD,BREED,COW,PARITY,CMONTH,CDAY,CYEAR,INT.,AGE,DAY,
    1YAM, YPM,N'/)
      DO 1960 I=1,100
          READ(4,1949)HERD,BREED,KOW,PARITY,CMONTH,CDAY,CYEAR,INT,AGE,
            1T(J),YAM(J),YPM(J),N
          1949 FORMAT(12,11,14,11,4I2,2I3,2F4.1,13)
          WRITE(6,1950) HERD,BREED,KOW,PARITY,CMONTH,CDAY,CYEAR,INT,AGE,
            1T(J), YAM(J), YPM(J),N
          1950 FORMAT(' ',12,11,14,11,4I2,2I3,2F4.1,13)
          1960 CONTINUE
          GO TO 6100
        6000 WRITE(6,6001)
        6001 FORMAT('0','ERROR IN READING DATA')
        6100 STOP
      END
C
C
C
C
      SUBROUTINE CONVRT(MO,IDAY,IYR,JDATE,JFEB)
      IYRQ=IYR/4
      JYR=4*IYRQ
      IF(JYR.EQ.IYR)GO TO 100

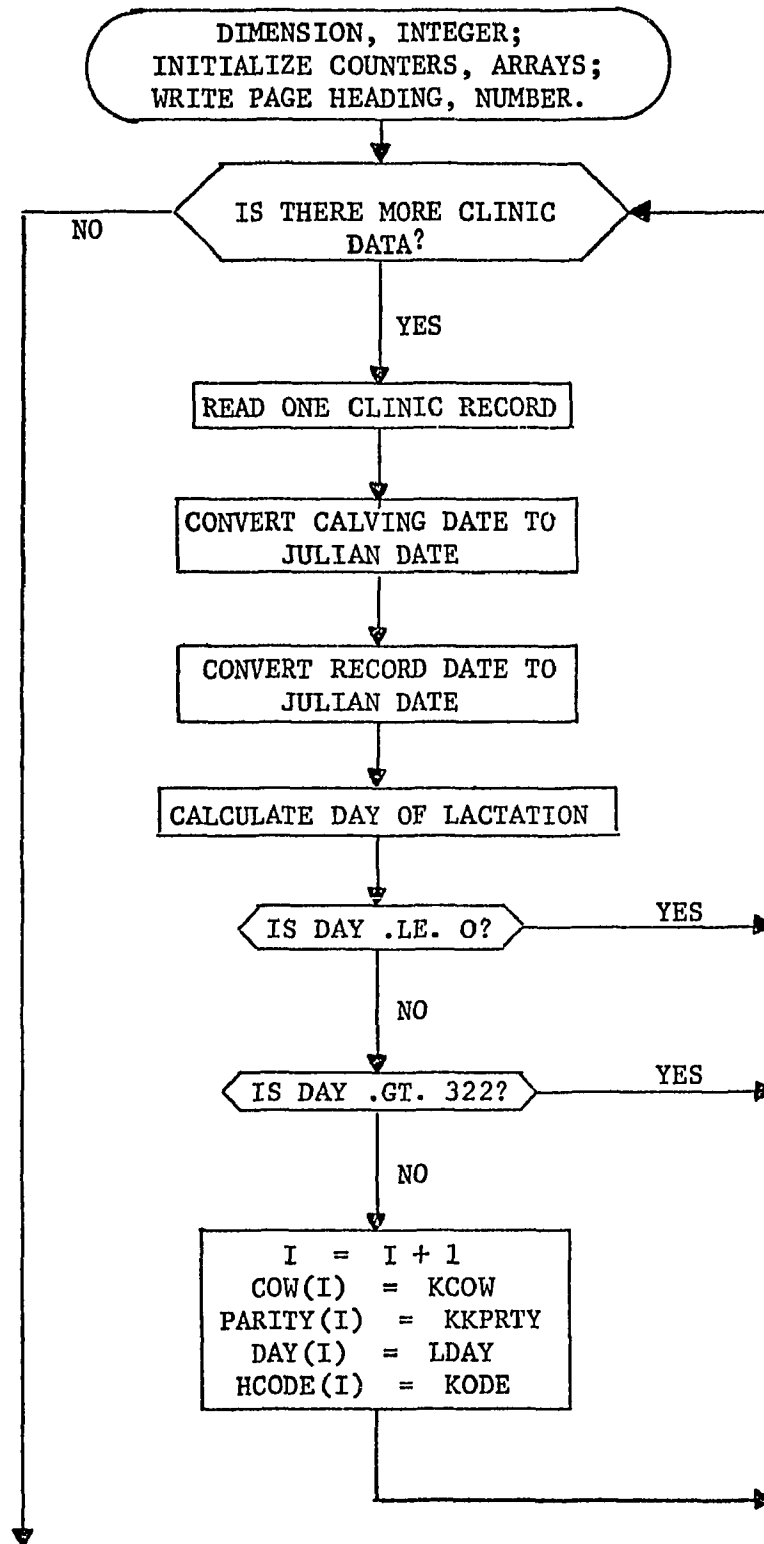
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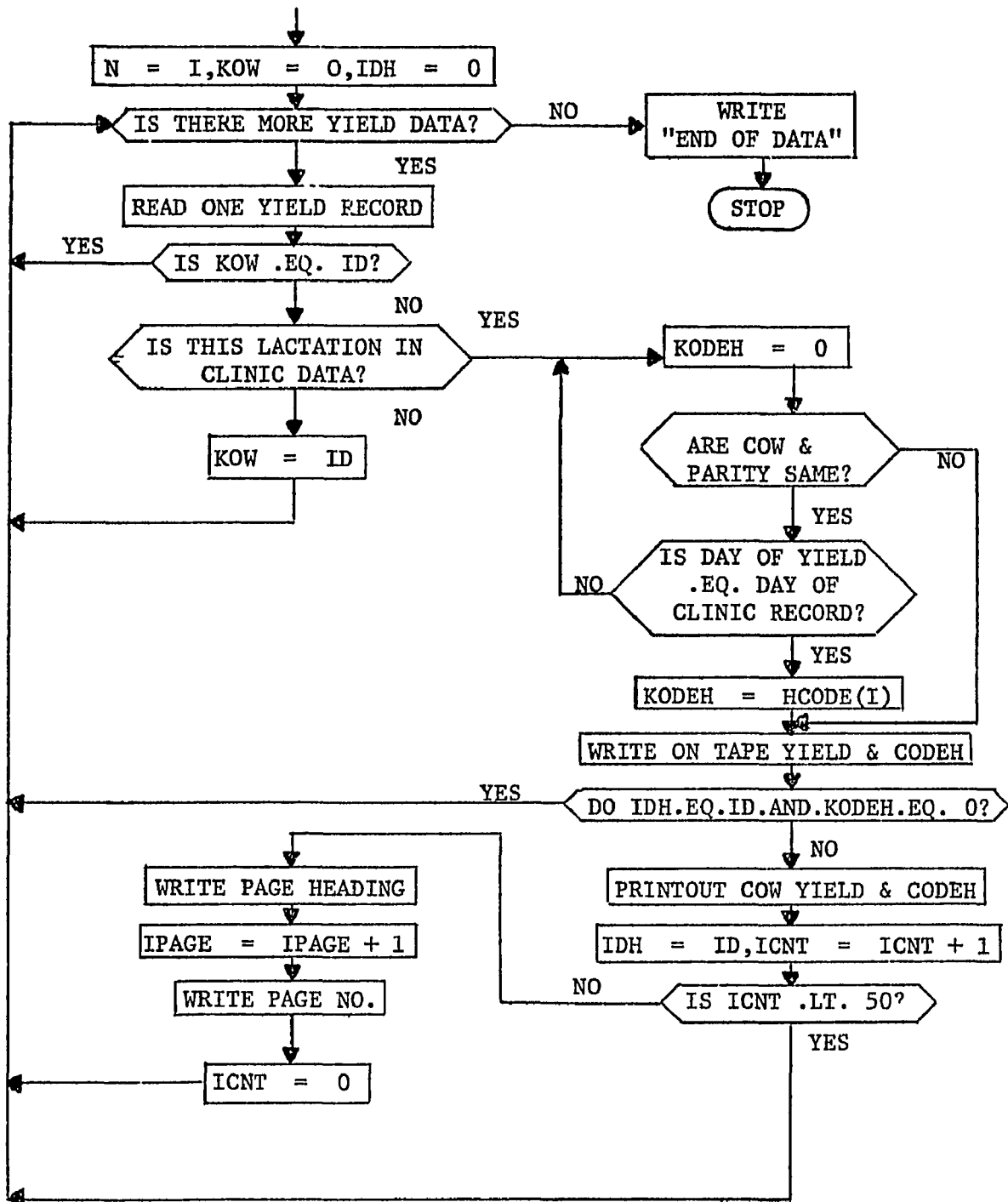
```

C   NON-LEAPYEAR
      JFEB=28
      GO TO 110
C   LEAPYEAR
100  JFEB=29
110  JDATE=IDAY+IYR*1000
111  IF(MO.EQ.01)GO TO 400
112  IF(MO.EQ.02)GO TO 390
113  IF(MO.EQ.03)GO TO 380
114  IF(MO.EQ.04)GO TO 370
115  IF(MO.EQ.05)GO TO 360
116  IF(MO.EQ.06)GO TO 350
117  IF(MO.EQ.07)GO TO 340
118  IF(MO.EQ.08)GO TO 330
119  IF(MO.EQ.09)GO TO 320
120  IF(MO.EQ.10)GO TO 310
121  IF(MO.EQ.11)GO TO 300
      JDATE=JDATE+30
300  JDATE=JDATE+31
310  JDATE=JDATE+30
320  JDATE=JDATE+31
330  JDATE=JDATE+31
340  JDATE=JDATE+30
350  JDATE=JDATE+31
360  JDATE=JDATE+30
370  JDATE=JDATE+31
380  JDATE=JDATE+JFEB
390  JDATE=JDATE+31
400  RETURN
      END
//GO.FT03F001 DD UNIT=TAPE,VOL=SER=028463,DSN=T5013.DAILYM,
// LABEL=(2,BLP,,IN),DCB=(RECFM=FB,LRECL=80,BLKSIZE=1600),
// DISP=(OLD,KEEP)
//GO.FT04F001 DD UNIT=TAPE,VOL=SER=028566,DSN=DAYLAC,
// DCB=(LRECL=35,RECFM=FB,BLKSIZE=3990),LABEL=(1,SL),DISP=(NEW,KEEP)
//GO.SYSIN DD *

```

Figure B2. Flow Diagram for Collating Clinic and Yield Data.





```

C
C
C
C LISTING 82. COLLATION OF CLINIC AND YIELD RECORDS.
C REGION=150K,TIME=22 MIN.,IOREQ=5000,COST=$55.32.
C NUMBER OF RECORDS APPROXIMATELY=55900.
C FORTRAN PROGRAM FOR COLLATING CLINIC DATA FROM CARDS WITH YIELD DATA
C FROM TAPE & WRITING RESULTS ON A SECOND TAPE.
// EXEC FORTLDGO,REGION=150K
//FORT.SYSIN DD *
C
C
C FORTRAN PROGRAM TO CONVERT CLINIC RECORD DATA TO DAY OF LACTATION
C AND GENERATE DATA FILE CONTAINING YIELD AND HEALTH DATA FOR THE 170
C LACTATIONS FOR WHICH HEALTH INFORMATION IS AT HAND.
  DIMENSION COW(800),PARITY(800),DAY(800),HCODE(800)
  INTEGER COW, PARITY, HCODE,AGE,AGEGRP,SEASON,DAY,CMD
  WRITE(6,2)
2  FORMAT('1','HERD BREED COW PARITY CMONTH INT. AGE DAY AMYLD P
1MYLD AGEGRP SEASON HLTH CODE')
  KOW=0
  IPAGE=1
  ICNT=0
  WRITE(6,3) IPAGE
3  FORMAT(' ',T121,'PAGE',I3)
  REWIND 3
  REWIND 4
  DO 5 I=1,800
    COW(I)=0
    PARITY(I)=0
    DAY(I)=0
    HCODE(I)=0
5  CONTINUE
  I=0
100 READ(5,105,END=2100) KHERD,KBREED,KCCW,KKPRTY, KMO,KDA,KYR,
1INTRVL,KIAGE,KODE,MO,IDAY,IYR
105 FORMAT(I2,I1,I4,I1,3I2,I2,I3,14X,I3,4X,3I2)
  CALL CONVRT(KMO,KDA,KYR,JCDATE,JCFEB)
  CALL CONVRT(MO,IDAY,IYR,JDATE,JFEB)
  JDIFF=JDATE-JCDATE
  IF(JDIFF.LE.0) GO TO 100
  IF(JDIFF.LT.600) GO TO 1300
  IF(JCFEB.EQ.29) GO TO 1260
  JDIFF=JDIFF-1
1260 JDIFF=JDIFF-634
  IF(JDIFF.GT.322) GO TO 100
1300 LDAY=JDIFF
  I=I+1
  COW(I)=KOW
  PARITY(I)=KKPRTY
  DAY(I)=LDAY
  HCODE(I)=KODE
  GO TO 100
2100 CONTINUE
  N=I
  IDH=0
2200 READ(3,2300,END=9000) IHRD,I8R,ID,IPAR,CMD,INT,AGE,LDAY,YAM,YPM,
1AGEGRP,SEASON
2300 FORMAT(I2,I1,I4,I1,2I2,2I3,2F4.1,I2,I1)
  IF(KOW.EQ.ID) GO TO 2200
C CHECK TO SEE IF THIS COW & PARITY APPEAR IN HEALTH DATA.

```

```

      DO 2400 I=1,N
      K=I
      IF(COW(I).EQ.ID.AND.PARITY(I).EQ.IPAR) GO TO 2500
2400 CONTINUE
      KOW=ID
      GO TO 2200
2500 CONTINUE
      DO 2550 I=K,N
      KODEH=0
      IF(COW(I).NE.ID.OR.PARITY(I).NE.IPAR) GO TO 2560
      IF(DAY(I).NE.LDAY) GO TO 2550
      KODEH=HCODE(I)
      GO TO 2560
2550 CONTINUE
2560 WRITE(4,2565) IHRD,IBR,ID,IPAR,CMO,INT,AGE,LDAY,YAM,YPM,AGEGRP,
      1 SEASON,KODEH
2565 FORMAT(I2,I1,I4,I1,2I2,2I3,2F4.1,I2,I1,I3)
      IF(IDH.EQ.ID.AND.KCCEH.EQ.0) GO TO 2200
      WRITE(6,2570) IHRD,IBR,ID,IPAR,CMO,INT,AGE,LDAY,YAM,YPM,AGEGRP,
      1 SEASON,KODEH
2570 FORMAT(' ',1X,I2,4X,I1,4X,I4,3X,I1,5X,I2,5X,I2,3X,I3,1X,I3,2X,
      1 F4.1,3X,F4.1,6X,I2,5X,I1,8X,I3)
      IDH=ID
      ICNT=ICNT+1
      IF(ICNT.LT.50) GO TO 2200
      WRITE(6,2)
      IPAGE=IPAGE+1
      WRITE(6,3) IPAGE
      ICNT=0
      GO TO 2200
9000 CONTINUE
      WRITE(6,9010)
9010 FORMAT(' ',10X,'END OF DATA')
      STOP
      END
      SUBROUTINE CONVRT(MO,IDAY,IYR,JDATE,JFEB)
      IYRQ=IYR/4
      JYR=4*IYRQ
      IF(JYR.EQ.IYR)GO TO 100
C   NON-LEAPYEAR
      JFEB=28
      GO TO 110
C   LEAPYEAR
      100 JFEB=29
      110 JDATE=IDAY+IYR*1000
      111 IF(MO.EQ.01)GO TO 400
      112 IF(MO.EQ.02)GO TO 390
      113 IF(MO.EQ.03)GO TO 380
      114 IF(MO.EQ.04)GO TO 370
      115 IF(MO.EQ.05)GO TO 360
      116 IF(MO.EQ.06)GO TO 350
      117 IF(MO.EQ.07)GO TO 340
      118 IF(MO.EQ.08)GO TO 330
      119 IF(MO.EQ.09)GO TO 320
      120 IF(MO.EQ.10)GO TO 310
      121 IF(MO.EQ.11)GO TO 300
      JDATE=JDATE+30
      300 JDATE=JDATE+31
      310 JDATE=JDATE+30
      320 JDATE=JDATE+31
      330 JDATE=JDATE+31

```

```
340 JDATE=JDATE+30
350 JDATE=JDATE+31
360 JOATE=JDATE+30
370 JOATE=JDATE+31
380 JDATE=JDATE+JFEB
390 JDATE=JDATE+31
400 RETURN
    END
//GO.FT03F001 CD UNIT=TAPE,VOL=SER=028463,DSN=SORTGRP,LABEL=(3,SL,,IN),
//  DCB=(LRECL=35,RECFM=FB,BLKSIZE=12250),DISP=(OLD,KEEP)
//GO.FT04F001 DD UNIT=TAPE,VOL=SER=028632,DSN=CLINCCDE,LABEL=(1,SL),
//  CCB=(LRECL=35,RECFM=FB,BLKSIZE=7000),DISP=(NEW,KEEP)
//GO.SYSIN DD *
```

APPENDIX C

EXAMPLE SAS REGRESSION ANALYSIS PROGRAM AND TABULATED
RESULTS OF THE REGRESSION ANALYSES

Listing C1 is an example of a SAS* regression analysis program; in this case, it runs regressions by season of calving, and season and parity. A set of nine "IF -- THEN" statements near the middle of the listing eliminates some lactations that do not fit into the parity or age group categories used in this study.

Table C1 contains all the regression coefficients calculated, plus the regression sums of squares and error degrees of freedom. Total cost of programs to calculate these values was approximately \$170.

*SAS is the Statistical Analysis System developed at North Carolina State University.

```

C
C
C
C LISTING C1. SAS REGRESSION PROGRAM.
C REGION=200K,TIME=28 MIN.,IOREQ=25000,COST=$72.62.
// EXEC SAS,REGION=200K
//SAS.LACDATA DD UNIT=TAPE,VOL=SER=028566,DSN=SORTSEA,DISP=(CLD,KEEP),
// LABEL=(3,SL,,IN),DCB=(LRECL=35,RECFM=FB,BLKSIZE=12250)
//SAS.YIELD DD UNIT=TAPE,VOL=SER=028632,DSN=SASSEAS,DISP=(NEW,KEEP),
// LABEL=(2,SL),DCB=(LRECL=2028,BLKSIZE=12168,RECFM=FB)
//SYSIN DD *
COMMENT SAS REGRESSION ON DATA SORTED BY SEASON(SORTSEA). REGRESSIONS
BY SEASON AND BY SEASON & PARITY;
DATA YIELD;
INPUT DDNAME=LACDATA PARITY 8 AGEGRP 27-28 SEASON 29 COW 4-7
DAY 16-18 AMYLD 19-22 PMYLD 23-26 AGE 13-15;
IF PARITY>3 THEN DELETE;
IF AMYLD<=0 THEN DELETE;
IF PMYLD<=0 THEN DELETE;
IF DAY <=0 THEN DELETE;
IF PARITY=1 & AGE>30 THEN DELETE;
IF PARITY=2 & AGE<35 THEN DELETE;
IF PARITY=2 & AGE>43 THEN DELETE;
IF PARITY=3 & AGE < 48 THEN DELETE;
IF PARITY= 3 & AGE > 56 THEN DELETE;
LNDAY=LOG(DAY);
LNYLD=LOG(AMYLD+PMYLD);
LNAMY=LOG(AMYLD);
LNPMY=LOG(PMYLD);
PROC REGR S;
BY SEASON;
MODEL LNYLD=LNDAY DAY;
TITLE'REGRESSION BY SEASON';
PROC REGR S;
BY SEASON PARITY;
MODEL LNYLD=LNDAY DAY;
TITLE'REGRESSION BY SEASON & PARITY';

```

Table C1. Results of Pooled Regression Analyses

Regression	Coefficients			Regression sums of squares	Error degrees of freedom
	a	b	c		
Pooled over all cells:	3.550	.159	.00393	7947.7559	157306
By parity:					
Parity 1	3.374	.155	.00311	2144.5239	84052
2	3.734	.160	.00487	4384.1500	47973
3	3.773	.173	.00492	2231.6083	25275
By Age Group:					
Age Gp 1	3.336	.162	.00308	827.5245	35346
2	3.415	.145	.00308	1084.6664	40467
3	3.339	.176	.00339	237.8923	8233
4	3.679	.165	.00510	2076.3316	20501
5	3.801	.146	.00466	1706.2273	19598
6	3.711	.182	.00478	616.4724	7868
7	3.699	.192	.00532	1073.2271	10566
8	3.753	.184	.00522	937.2619	9583
9	3.959	.113	.00356	256.4532	5120
By Season:					
Season 1	3.555	.173	.00426	2103.6904	36118
2	3.515	.160	.00377	1482.3967	33418
3	3.530	.135	.00340	1409.2663	36390
4	3.584	.165	.00418	3012.7665	51371
By Season & Parity:					
Season Parity					
1 1	3.362	.176	.00346	611.6356	19979
1 2	3.782	.168	.00524	1223.0390	11392
1 3	3.805	.180	.00529	482.8098	4741
2 1	3.304	.169	.00339	553.9862	18295
2 2	3.814	.122	.00391	593.4662	9639
2 3	3.696	.196	.00474	395.4967	5478
3 1	3.379	.133	.00262	358.3364	20143
3 2	3.692	.136	.00469	892.8506	9647
3 3	3.727	.145	.00400	374.5797	6594
4 1	3.430	.147	.00303	642.2705	25626
4 2	3.681	.189	.00525	1716.9090	17286
4 3	3.835	.178	.00558	1038.4686	8453

Table C1 (Continued)

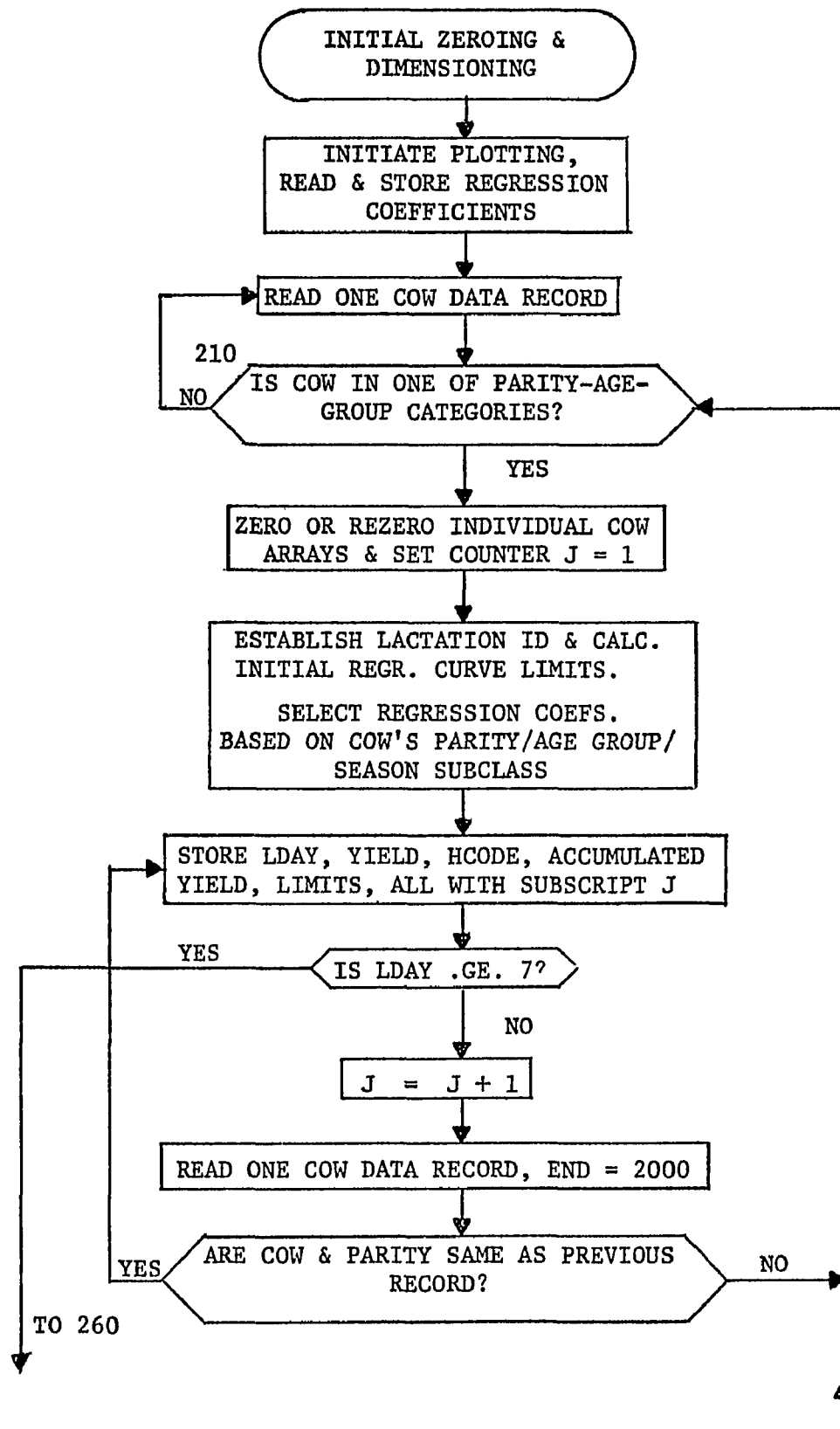
Regression			Coefficients			Regression	Error degrees
			a	b	c	sums of squares	of freedom
By 36 subclasses:							
parity age season							
group							
1	1	1	3.260	.196	.00367	346.2625	19643
1	1	2	3.320	.149	.00293	148.7639	6706
1	1	3	3.344	.134	.00260	120.7381	7012
1	1	4	3.413	.154	.00290	224.8053	10976
1	2	1	3.485	.151	.00320	238.1317	8417
1	2	2	3.326	.166	.00350	292.3557	8536
1	2	3	3.392	.129	.00263	202.4294	10688
1	2	4	3.448	.141	.00309	359.1431	12817
1	3	1	3.417	.166	.00332	26.6511	913
1	3	2	3.206	.219	.00406	120.6088	3047
1	3	3	3.428	.151	.00260	35.9724	2437
1	3	4	3.405	.143	.00336	64.8621	1827
2	4	1	3.598	.213	.00597	849.3893	6620
2	4	2	3.770	.092	.00420	198.2969	2354
2	4	3	3.764	.100	.00449	416.3667	4220
2	4	4	3.665	.187	.00501	646.4086	7298
2	5	1	4.047	.100	.00439	355.2032	3854
2	5	2	3.849	.116	.00364	259.4244	4863
2	5	3	3.740	.132	.00490	375.8981	3595
2	5	4	3.658	.201	.00541	752.2443	7277
2	6	1	3.970	.137	.00363	42.3218	912
2	6	2	3.745	.180	.00446	156.2115	2416
2	6	3	3.415	.234	.00484	117.1851	1826
2	6	4	3.777	.169	.00549	326.2784	2705
3	7	1	3.772	.195	.00596	307.0158	2342
3	7	2	3.737	.179	.00547	248.4577	2126
3	7	3	3.333	.244	.00488	153.0718	2437
3	7	4	3.859	.168	.00519	389.6782	3652
3	8	1	3.757	.189	.00505	154.1856	1786
3	8	2	3.580	.219	.00424	96.2549	2129
3	8	3	3.871	.103	.00425	94.3884	1166
3	8	4	3.786	.194	.00610	652.3451	4493
3	9	1	4.000	.127	.00389	36.5674	607
3	9	2	3.822	.188	.00440	73.6666	1217
3	9	3	3.985	.082	.00320	137.0267	2985
3	9	4	4.126	.113	.00343	14.0666	302

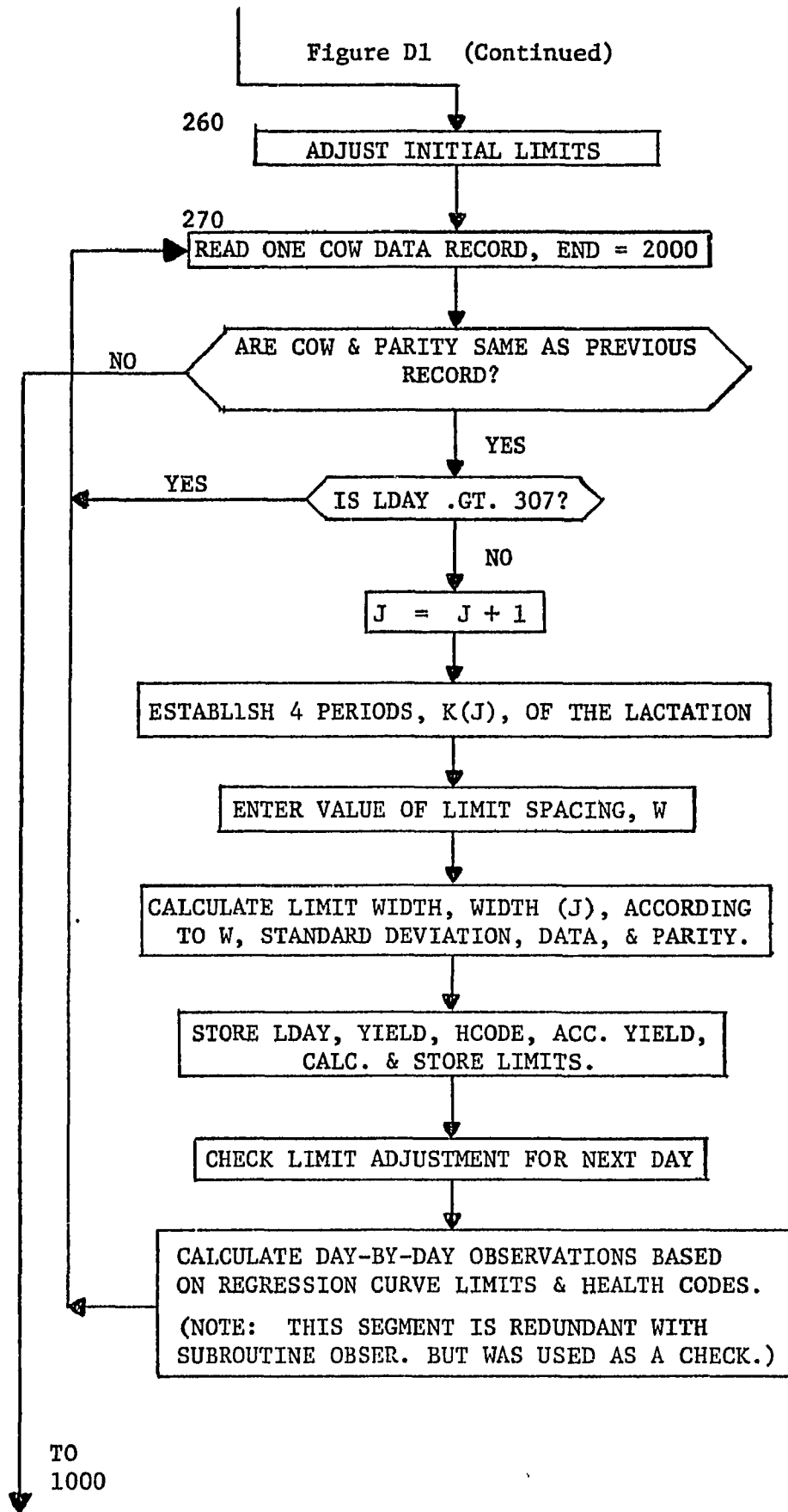
APPENDIX D

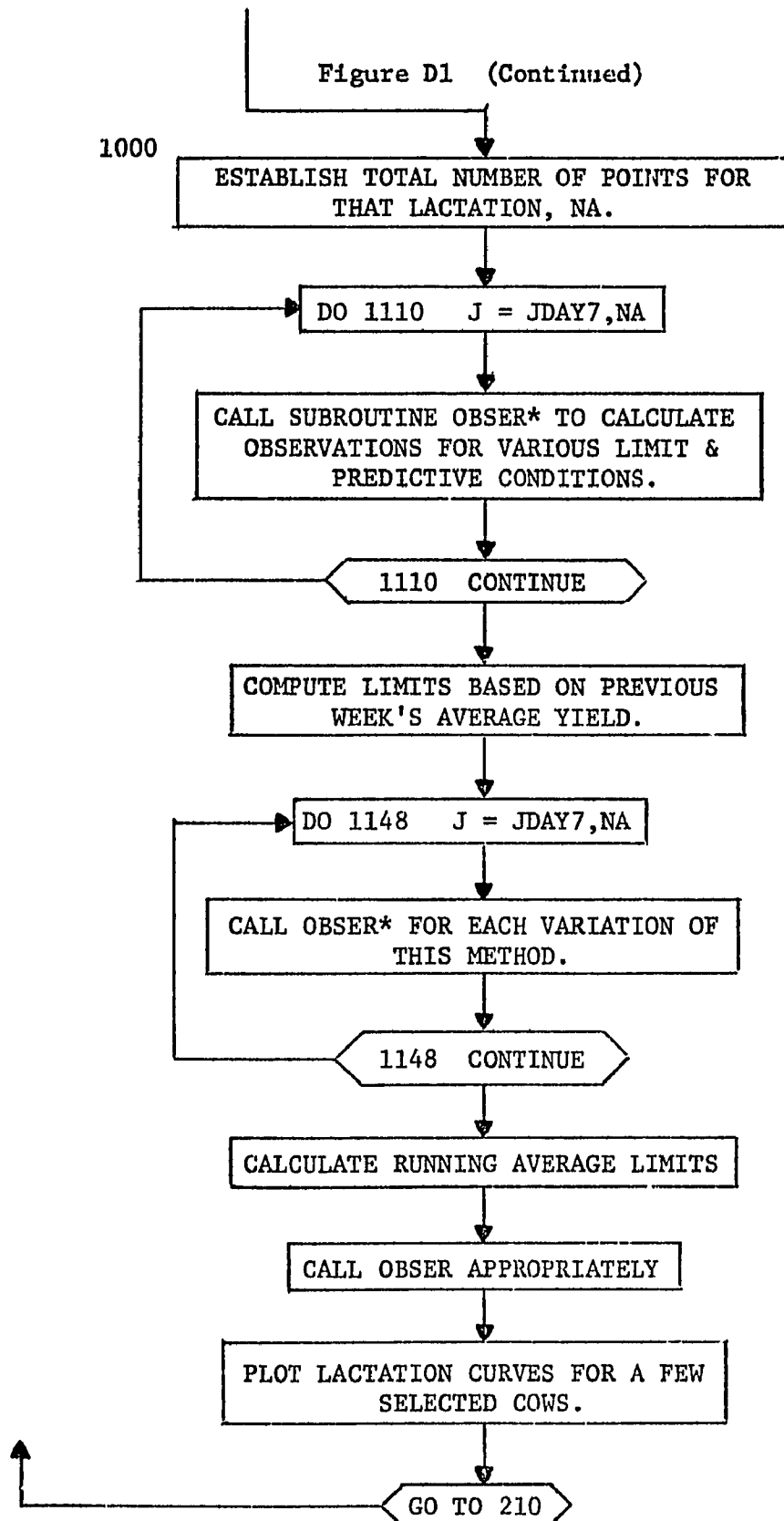
CONTINGENCY ANALYSIS PROGRAMMING AND COMPLETE CONTINGENCY TABLES

Figure D1 is the flow diagram for the main contingency analysis program; Figure D2 is the flow diagram for the associated observation generating subroutine; and Figure D3 is the flow diagram for the table generating and printout subroutine. Listing D1 is the listing for the complete contingency program including the two subroutines. Following that listing are Tables D1 through D25 which are the summary contingency tables for the 25 methods of analysis used. Tables D26 through D50 are the detailed contingency tables for these methods.

Figure D1. Flow Diagram for Contingency Table Main Program.







*Note that a separate observation array is needed for each analysis method; i.e., ANOBS, CKOBS, BLOBS, etc. This occurs because the observations are accumulative.

Figure D1 (Continued)

2000

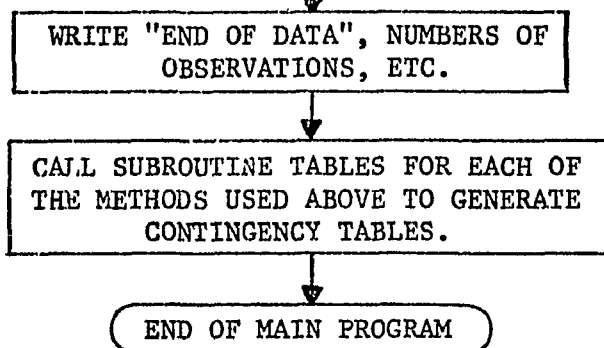


Figure D2. Flow Diagram for Subroutine OBSER.

INPUTS ARE: YLD, HCODE, DLIMIT, K, J, JANT, OBS.
 THEY ARE, RESPECTIVELY:
 DAILY MILK YIELD, HEALTH CODE, LOWER COMPARISON
 LIMIT, PERIOD OF LACTATION 'K', DAY OF
 LACTATION, SUBSCRIPT 'J', NUMBER OF DAYS
 PREDICTIVE 'JANT', AND THE OBSERVATION ARRAY
 'OBS'.

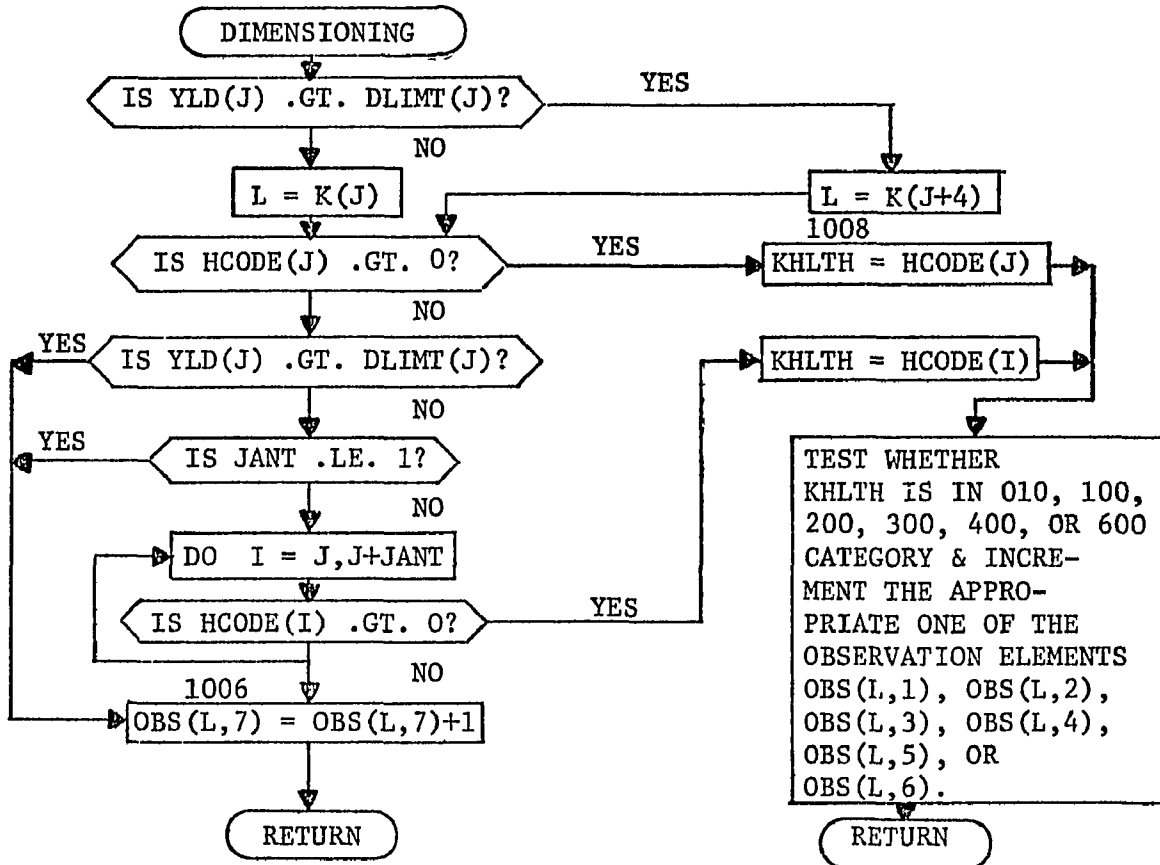
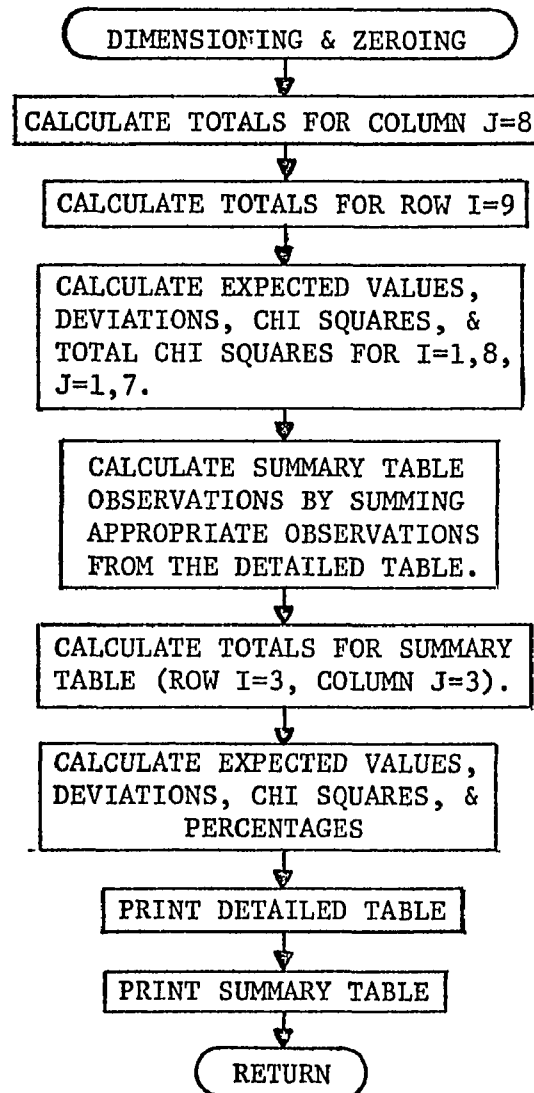


Figure D3. Flow Diagram for Subroutine TABLES.

INPUTS ARE OBS & AMETH, WHICH ARE, RESPECTIVELY, THE APPROPRIATE OBSERVATION ARRAY AND THE METHOD IDENTIFICATION NUMBER.

THE DETAILED CONTINGENCY TABLES CONTAIN 8 ROWS AND 7 COLUMNS IN THE MAIN BODY (I ROWS, J COLUMNS). THE J=8 COLUMN AND THE I=9 ROW ARE TOTALS. THE "OBS" DATA FOR I=1,8 AND J=1,7 ARE SUPPLIED FROM SUBROUTINE OBSER OR THE MAIN PROGRAM.



```

C
C
C
C LISTING D1. CONTINGENCY ANALYSIS AND PLOTTING OF SELECTED COWS.
C REGION=150K,TIME=7 MIN.,IOREQ=600,LINES=5000,COST=$16.93.
// EXEC FORTLDPT,PARM.PLOT='PL=120,COPIES=1,TIME=30.00,SPECIAL=NO ',
// LIBFILE='USER.P3511.PLOTS',REGION=150K
//FORT.SYSIN DD *
C FORTRAN PROGRAM TO GENERATE CONTINGENCY TABLE INCLUDING CHI-SQUARE
C FOR VARIOUS METHODS OF ANALYZING COW PERFORMANCE DATA--DAILY MILK
C YIELD. DATA INPUT ARE HEALTH CODED RECORDS ON 170 LACTATIONS.
C THIS FORTRAN PROGRAM GENERATES LIMITS, COMPARES COW PRODUCTION TO THE
C LIMITS, COMPARES LIMIT RESULTS WITH CLINIC RECORDS, AND GENERATES A
C CONTINGENCY TABLE FOR THE ANALYSIS METHOD USED. (BEGUN 1 MAY 75 GMH).
  DIMENSION ANYLD(325),PMYLD(325),T(325),DNLIM(325),UPLIM(325),
  1 INDEX(36),A(36),B(36),C(36),YLD(325),HCODE(325),SOBS(3,3)
  INTEGER COW, PARITY,HCODE,AGE,AGEGRP,SEASON,DAY,CMO,K(325)/325*0./
  REAL ACCYLD(325)/325*0./,FLAG(325)/325*0./,SCX(2),SCY(2),SAC(2),
  1SLGX(2),SLGY(2),X(2),Y(2), OBS(10,10)/100*0./,ANOBS(10,10)/100*0./
  2, CKOBS(10,10)/100*0./,BLOBS(10,10)/100*0./,SUMOBS(3,3)/9*0./
  REAL DEV(10,10)/100*0./, E(10,10)/100*0./,CHISQ(10,10)/100*0./
  REAL SUMEXP(2,2)/4*0./,SUMDEV(2,2)/4*0./, SCHISQ(2,2)/4*0./,
  1 PCNT(3,3)/9*0./,WIDTH(325)/325*0./
  REAL BFLAG(325)/325*0./, RLIM(325)/325*0./, CCODE(325)/325*6./
  REAL ROB3(10,10)/100*0./,ROB3P(10,10)/100*0./,ROB7(10,10)/100*0./,
  1ROB7P(10,10)/100*0./,RLIM3(325)/325*0./,RLIM7(325)/325*0./,
  2 RFLAG(325)/325*0./
  READ(5,99) NN
99 FORMAT(I5)
  READ(5,100) (INDEX(I),A(I),B(I),C(I),I=1,NN)
100 FORMAT(25X,I3,2X,2F5.3,F5.4)
  CALL PLOT(2.0,2.0,-3)
  NUBS=0
  NZCOD=0
  NNZCO=0
  NREC=0
  NCOH=0
  NCODE=0
  CONST=0.
  GTOTAL=0.
  TCHISQ=0.
C END OF INITIATION PROCEDURES.
C BEGIN READING COW DATA.
150 READ(3,200,ERR=6000,END=2000) IHERD,IBR,ID,IPAR,CMO,JNT,AGE,LDAY,
  1 YAM,YPM,AGEGRP,SEASON,KODEH
200 FORMAT(I2,I1,I4,I1,2I2,2I3,2F4.1,I2,I1,I3)
210 CONTINUE
  IF(IPAR.EQ.1.AND.AGE.GT.30) GO TO 150
  IF(IPAR.EQ.2.AND.AGE.LT.35) GO TO 150
  IF(IPAR.EQ.2.AND.AGE.GT.43) GO TO 150
  IF(IPAR.EQ.3.AND.AGE.LT.48) GO TO 150
  IF(IPAR.EQ.3.AND.AGE.GT.56) GO TO 150
C ZERO OR REZERO THE INDIVIDUAL COW ARRAYS AND THE COUNTER J.
  DO 212 J=1,325
  YLD(J)=0.
  T(J)=0.
  HCODE(J)=0.
  DNLIM(J)=0.
  UPLIM(J)=0.
  ACCYLD(J)=0.
  FLAG(J)=0.

```

```

212 CONTINUE
  J=1
C ESTABLISH LACTATION IDENTIFICATION & CALCULATE INITIAL LIMITS.
CC  KDEX=100*IPAR+10*AGEGRP+SEASON
    NCOW=NCOW+1
    COW=ID
    PARITY=IPAR
    DO 220 I=1,NN
      II=I
      IF((100*IPAR).EQ.INDEX(I)) GO TO 230
CC  IF(KDEX.EQ.INDEX(I)) GO TO 230
      IF(IPAR.GE.3) II=3
220 CONTINUE
230 CONTINUE
C REMOVE C'S FROM FOLLOWING 3 CARDS TO WRITE COW, INDEX, & REGR. COEFS.
CC  WRITE(6,231) COW, PARITY, INDEX(II), A(II),B(II),C(II)
CC231 FORMAT(' ', 'COW= ',I4,' PARITY= ',I2,' INDEX= ',I3,' A(II)= ',
CC  1 F5.3,' B(II)= ',F5.3,' C(II)*10 = ',F5.4)
250 YLD(J)=YAM+YPM
    HCODE(J)=KODEH
    IF(KODEH.GT.0) NCODE=NCODE+1
    T(J)=LDAY
    ACCYLD(1)=YLD(1)
    NREC=NREC+1
    IF(J.L1.2) GO TO 252
    ACCYLD(J)=ACCYLD(J-1)+YLD(J)
CC  DNLIM(J)=(T(J)**B(II)*EXP(A(II)-C(II)*0.1*T(J)))-5.0
252 DNLIM(J)=(T(J)**B(II)*EXP(A(II)-C(II)*0.1*T(J)))-3.0
CC  UPLIM(J)=DNLIM(J)+10.
    UPLIM(J)=DNLIM(J)+06.
    IF(LDAY.GE.7) GO TO 260
    J=J+1
    READ(3,200,ERR=6000,END=2000) IHERD,IBR,ID,IPAR,CMO,INT,AGE,LDAY,
    1 YAM,YPM,AGEGRP,SEASON,KODEH
    IF(COW.EQ.ID.AND.PARITY.EQ.IPAR) GO TO 250
    GO TO 210
C ADJUST INITIAL LIMITS.
260 CONTINUE
    JDAY7=J+1
    CONST=YLD(J)-(T(J)**B(II)*EXP(A(II)-C(II)*0.1*T(J)))
270 CONTINUE
    READ(3,200,ERR=6000,END=2000) IHERD,IBR,ID,IPAR,CMO,INT,AGE,LDAY,
    1 YAM,YPM,AGEGRP,SEASON,KODEH
    IF(COW.NE.ID.OR.PARITY.NE.IPAR) GO TO 1000
    IF(LDAY.GT.307) GO TO 270
    J=J+1
    IF(LDAY.LE.82) K(J)=1
    IF(LDAY.GT.82.AND.LDAY.LE.157) K(J)=2
    IF(LDAY.GT.157.AND.LDAY.LE.232) K(J)=3
    IF(LDAY.GT.232.AND.LDAY.LE.307) K(J)=4
CCCCCCCCC
    W=4.
CCCCCCCCC
    IF(IPAR.GT.1) GO TO 275
    IF(LDAY.LE.82) WIDTH(J)=W*2.36
    IF(LDAY.GT.82.AND.LDAY.LE.157) WIDTH(J)=W*1.84
    IF(LDAY.GT.157.AND.LDAY.LE.232) WIDTH(J)=W*1.67
    IF(LDAY.GT.232.AND.LDAY.LE.307) WIDTH(J)=W*1.58
    GO TO 280
275 CONTINUE
    IF(LDAY.LE.82) WIDTH(J)=W*3.59

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      IF(LDAY.GT.82.AND.LDAY.LE.157)WIDTH(J)=W*2.72
      IF(LDAY.GT.157.AND.LDAY.LE.232)WIDTH(J)=W*2.44
      IF(LDAY.GT.232.AND.LDAY.LE.307)WIDTH(J)=W*2.08
280  YLD(J)=YAM+YPM
      HCODE(J)=KODEH
      IF(KODEH.GT.0) NCODE=NCODE+1
      T(J)=LDAY
      ACCYLD(J)=ACCYLD(J-1)+YLD(J)
      NREC=NREC+1
      NOBS=NOBS+1
      IF(KODEH.EQ.0)NZCOD=NZCOD+1
      IF(KODEH.GT.0) NNZCD=NNZCD+1
CC   DNLIM(J)=(T(J)**B(II)*EXP(A(II)-C(II)*0.1*T(J)))-5.0+CONST
      DNLIM(J)=(T(J)**B(II)*EXP(A(II)-C(II)*0.1*T(J)))-3.0+CONST
      IF(DNLIM(J).LT.0.)DNLIM(J)=0.
CC   UPLIM(J)=DNLIM(J)+10.
CC   UPLIM(J)=DNLIM(J)+06.
      UPLIM(J)=DNLIM(J)+WIDTH(J)
C   CHECK UPWARD & DONWARD LIMITS.
      IF(YLD(J).GT.UPLIM(J)) CONST=CONST+1.0
      IF(YLD(J-2).LT.DNLIM(J-2).AND.YLD(J-1).LT.DNLIM(J-1).AND.YLD(J).LT
        1.DNLIM(J)) CONST=CONST-5.0
C   THIS SEGMENT THROUGH STATEMENT 510 COMPUTES DAY-BY-DAY OBSERVATIONS
C   BASED ON REGRESSION CURVE LIMITS & HEALTH CODES.
      L=K(J)
      IF(YLD(J).GT.DNLIM(J)) L=K(J)+4
C   TO FLAG ON UP-SIDE.
CC   IF(YLD(J).GT.UPLIM(J)) L=K(J)
490  IF(HCODE(J).GT.0) GO TO 500
      OBS(L,7)=OBS(L,7)+1.
      GO TO 511
500  IF(HCODE(J).LT.100) OBS(L,1)=OBS(L,1)+1.
      IF(HCODE(J).GE.100.AND.HCODE(J).LT.200) OBS(L,2)=OBS(L,2)+1.
      IF(HCODE(J).GE.200.AND.HCODE(J).LT.300) OBS(L,3)=OBS(L,3)+1.
      IF(HCODE(J).GE.300.AND.HCODE(J).LT.400) OBS(L,4)=OBS(L,4)+1.
      IF(HCODE(J).GE.400.AND.HCODE(J).LT.600) OBS(L,5)=OBS(L,5)+1.
510  IF(HCODE(J).GE.600) OBS(L,6)=OBS(L,6)+1.
511  GO TO 270
1000 NA=J
      N=305
      IF(NA.LT.305) N=NA
      DO 1110 J=JDAY7,NA
C       JANT=0
C       CALL OBSER (YLD,HCODE,DNLIM,K,J, JANT, CKOBS)
      JANT=6
      CALL OBSER (YLD,HCODE,DNLIM,K,J, JANT, ANOBS)
1110 CONTINUE
C   THIS SEGMENT COMPUTES LIMITS BASED          ON PREVIOUS WEEK'S AVERAGE
C   DAILY YIELD.
C   TO CALCULATE THESE LIMITS, PUT A "C" IN COL.1 OF THE FOLLOWING "GO
C   TO" CARD, AND SEE ALSO"CALL TABLES"STATEMENTS AT END OF MAIN.
CC   GO TO 1148
      JI=1
      JF=JI+6
1144 CONTINUE
      SUM=0.
      DO 1145 J=JI,JF
      SUM=SUM+YLD(J)
1145 CONTINUE
      JI=JI+7
      JF=JI+6

```

```

      DO 1146 J=JI,JF
C      BLIM(J)=0.9*SUM/7.
      BLIM(J)=SUM/7.-WIDTH(J)/2.
1146  CONTINUE
      IF(J1.GE.309) GO TO 1147
      GO TO 1144
1147  CONTINUE
C  THIS SEGMENT TESTS YLD(J) TO SEE IF IT IS BELOW LIMIT.
      DO 1148 J=JDAY7,NA
      JANT=6
      CALL OBSER (YLD,HCODE,BLIM,K,J, JANT, BLOBS)
      JANT=0
C      CALL OBSER (YLD,HCODE,BLIM,K,J, JANT, ANOBS)
1148  CONTINUE
C  THIS SEGMENT CALCULATES RUNNING AVERAGE LIMITS, 3-DAY & 7-DAY
C  RLIM3(J) & RLIM7(J).
C  TO CALCULATE THESE LIMITS, PUT A "C" IN COL.1 OF THE FOLLOWING "GO
C  TO" CARD, AND SEE ALSO"CALL TABLES"STATEMENTS AT END OF MAIN.
CC    GO TO 1156
      DO 1150 J=JDAY7,14
      RLIM3(J)=0.
      RLIM7(J)=0.
      RLIM3(J)=(YLD(J-3)+YLD(J-2)+YLD(J-1))*1.0/3.-WIDTH(J)/2.
      RLIM7(J)=RLIM3(J)
1150  CONTINUE
      DO 1152 J=14,NA
      RLIM3(J)=0.
      RLIM7(J)=0.
      RLIM3(J)=(YLD(J-3)+YLD(J-2)+YLD(J-1))*1.0/3.-WIDTH(J)/2.
      RLIM7(J)=(YLD(J-7)+YLD(J-6)+YLD(J-5)+YLD(J-4)+YLD(J-3)+YLD(J-2)+
1  YLD(J-1))*1.0/7.-WIDTH(J)/2.
1152  CONTINUE
      DO 1154 J=JDAY7, NA
      JANT=0
CC    CALL OBSER(YLD,HCODE,RLIM3,K,J,JANT,ROB3 )
CC    CALL OBSER(YLD,HCODE,RLIM7,K,J,JANT,ROB7 )
      JANT=6
      CALL OBSER(YLD,HCODE,RLIM3,K,J,JANT,ROB3P)
      CALL OBSER(YLD,HCODE,RLIM7,K,J,JANT,ROB7P)
1154  CONTINUE
C  THIS SEGMENT PLOTS 3 SELECTED COWS, 3 LACTATIONS EACH.
1156  IF(COW.EQ.4072.OR.COW.EQ.4017.OR.COW.EQ.4219)GO TO 1200
      GO TO 210
1200  DO 1250 J=7,N
      FLAG(J)=0.
      CCODE(J)=6.
      IF(HCODE(J).GT.0) CCODE(J)=6.+.01*HCODE(J)
      IF(YLD(J).LT.DNLIM(J))FLAG(J)=5.
C      BFLAG(J)=0.
C      IF(YLD(J).LT.BLIM(J)) BFLAG(J)=5.0
C      RFLAG(J)=0.
C      IF(YLD(J).LT.RLIM7(J)) RFLAG(J)=5.0
1250  CONTINUE
      SCX(1)=0.0
      SCX(2)=40.
      SCY(1)=0.
      SCY(2)=20.
      SAC(1)=0.
      SAC(2)=4000.
      SLGX(1)=0.
      SLGX(2)=1.

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SLGY(1)=0.
SLGY(2)=1.
CALL ZIP(5,256,1,1)
CALL CCP5AX(0.0,0.0,'TIME(DAYS)',-10,8.1,0.0,SCX)
CALL CCP5AX(0.0,0.0,'MILK YIELD(LB)',14,5.0,90.0,SCY)
CALL CCP5AX(8.1,0.0,'ACCUMULATED YIELD(LB)',-21,5.0,90.0,SAC)
CALL PLOT(0.0,5.0,3)
CALL PLOT(8.1,5.0,2)
CALL CCP6LI(T,ACCYLD,N,-1,SCX,SAC,0.20)
CALL CCP6LI(T,YLD,N,1,SCX,SCY)
CALL CCP6LI(T,FLAG,N,-1,SCX,SCY)
CALL CCP6LI(T,CCODE,N,1,SCX,SCY)
CALL CCP6LI(T,DNLIM,N,1,SCX,SCY,0.05)
CALL CCP6LI(T,UPLIM,N,-1,SCX,SCY,0.05)
C CALL CCP6LI(T,BLIM,N,1,SCX,SCY,0.05)
C CALL CCP6LI(T,BFLAG,N,-1,SCX,SCY)
C CALL CCP6LI(T,RLIM7,N,1,SCX,SCY,0.05)
C CALL CCP6LI(T,RFLAG,N,-1,SCX,SCY)
CALL SYMBOL(0.15,4.70,0.15,'COW NO. ',0.0,8)
CALL CCP3NR(0.,0.,-0.15,1.*COW,0.,-1)
CALL SYMBOL(0.15,4.475,0.15,'PARITY ',0.0,7)
CALL CCP3NR(0.,0.,-0.15,1.*PARITY,0.,-1)
CALL SYMBOL(5.0,4.7,0.15,'YIELD OR FLAG|FLIMITS |FACCUM. YIELD ',
1 0.0,37)
CALL SYMBOL(7.0,0.33,0.15,'CLINIC, |FANALYSIS ',0.0,19)
X(1)=3.9
X(2)=4.95
Y(1)=4.7
Y(2)=Y(1)
CALL CCP6LI(X,Y,2,-1,SLGX,SLGY)
Y(1)=4.7-1.5*.15
Y(2)=Y(1)
CALL CCP6LI(X,Y,2,-1,SLGX,SLGY,0.05)
Y(1)=4.7-1.5*.15*2.
Y(2)=Y(1)
CALL CCP6LI(X,Y,2,-1,SLGX,SLGY,0.20)
CALL PLOT(11.,0.0,-3)
GO TO 210
2000 WRITE(6,2001) NCOW,NREC,NCODE,NUBS,NNZCD,NZCOD
2001 FORMAT('0',10X,'END OF DATA',5X,'NUMBER OF COWS= ',I5,5X,'NUMBER O
1F RECORDS ',I10,5X,'NUMBER OF NON-ZERO HEALTH CODES= ',I5/,
1 10X,'NUMBER OF OBSERVATIONS USED= ',I10,5X,'NUMBFR OF NON-ZERO',
2' HEALTH CODES USED= ',I5/5X,'NUMBER OF ZERO HEALTH CODES USED= ',
3 I7)
AMETH=3421.
CALL TABLES(OBS,AMETH)
AMETH=3011.
C CALL TABLES (CKOBS,AMETH)
AMETH=2042.
CALL TABLES(BLOBS,AMETH)
AMETH=3422.
CALL TABLES(ANOBS,AMETH)
AMETH=1121.
C CALL TABLES(ROB3 ,AMETH)
AMETH=1132.
CALL TABLES(ROB3P,AMETH)
AMETH=1221.
C CALL TABLES(ROB7 ,AMETH)
AMETH=1232.
CALL TABLES(ROB7P,AMETH)
GO TO 7000

```

```

6000 WRITE(6,6100)
6100 FORMAT('0',10X,'TAPE READING ERROR, GMH')
      GO TO 270
7000 STOP
      END
      SUBROUTINE OBSER (YLD,HCODE,DLIMIT,K,J, JANT, OBS)
      INTEGER K(325),HCODE(325)
      REAL YLD(325),DLIMIT(325), OBS(10,10)
      L=K(J)
      IF(YLD(J).GT.DLIMIT(J)) L=K(J)+4
      IF(HCODE(J).GT.0) GO TO 1008
      IF(YLD(J).GT.DLIMIT(J)) GO TO 1006
      JN=J+JANT
      IF(JANT.LE.1) GO TO 1006
      DO 1005 I=J,JN
      IF(HCODE(I).GT.0) GO TO 1009
1005 CONTINUE
1006 OBS(L,7)=OBS(L,7)+1.
      GO TO 1050
1008 KHLTH=HCODE(J)
      GO TO 1010
1009 KHLTH=HCODE(I)
1010 IF(KHLTH.LT.100) OBS(L,1)=OBS(L,1)+1.
      IF(KHLTH.GE.100.AND.KHLTH.LT.200) OBS(L,2)=OBS(L,2)+1.
      IF(KHLTH.GE.200.AND.KHLTH.LT.300) OBS(L,3)=OBS(L,3)+1.
      IF(KHLTH.GE.300.AND.KHLTH.LT.400) OBS(L,4)=OBS(L,4)+1.
      IF(KHLTH.GE.400.AND.KHLTH.LT.600) OBS(L,5)=OBS(L,5)+1.
      IF(KHLTH.GE.600) OBS(L,6)=OBS(L,6)+1.
1050 CONTINUE
      RETURN
      END
      SUBROUTINE TABLES (OBS,AMETH)
      REAL OBS(10,10), SUMOBS(3,3)
      REAL DEV(10,10)/100*0./,E(10,10)/100*0./,CHISQ(10,10)/100*0./,
1 SUMEXP(2,2)/4*0./,SUMDEV(2,2)/4*0./,SCHISQ(2,2)/4*0./,
2 PCNT(3,3)/9*0./,SOBS(3,3)/9*0./
      GTOTAL=0.
      SGTOT=0.
      TCHISQ=0.
C CALCULATION OF TABLE OF OBSERVATIONS & TABLE TOTALS.
      DO 2100 I=1,8
      DO 2100 J=1,7
      OBS(I,8)=OBS(I,8)+OBS(I,J)
2100 CONTINUE
      DO 2160 J=1,8
      DO 2160 I=1,8
      OBS(9,J)=OBS(9,J)+OBS(I,J)
2160 CONTINUE
      DO 2170 J=1,7
      GTOTAL=GTOTAL+OBS(9,J)
2170 CONTINUE
C CALCULATION OF EXPECTED VALUES.
      DO 2200 I=1,8
      DO 2200 J=1,7
      E(I,J)=OBS(I,8)*OBS(9,J)/GTOTAL
      IF(E(I,J).LE.0.000) E(I,J)=0.01
      DEV(I,J)=OBS(I,J)-E(I,J)
      CHISQ(I,J)=(OBS(I,J)-E(I,J))*(OBS(I,J)-E(I,J))/E(I,J)
      TCHISQ=TCHISQ+CHISQ(I,J)
2200 CONTINUE
C CALCULATE SUMMARY TABLE, OBSERVATIONS.

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```

      DO 2201 I=1,3
      DO 2201 J=1,3
      SUMOBS(I,J)=0.
2201 CONTINUE
      DO 2202 I=1,4
      DO 2202 J=1,6
      SUMOBS(1,1)=SUMOBS(1,1)+OBS(I,J)
2202 CONTINUE
      DO 2204 I=5,8
      DO 2204 J=1,6
      SUMOBS(2,1)=SUMOBS(2,1)+OBS(I,J)
2204 CONTINUE
      DO 2206 I=1,4
      SUMOBS(1,2)=SUMOBS(1,2)+OBS(I,7)
2206 CONTINUE
      DO 2208 I=5,8
      SUMOBS(2,2)=SUMOBS(2,2)+OBS(I,7)
2208 CONTINUE
      DO 2210 I=1,2
      DO 2210 J=1,2
      SUMOBS(1,3)=SUMOBS(1,3)+SUMOBS(I,J)
2210 CONTINUE
      DO 2212 J=1,3
      DO 2212 I=1,2
      SUMOBS(3,J)=SUMOBS(3,J)+SUMOBS(I,J)
2212 CONTINUE
      DO 2213 J=1,2
      SGTOT=SGTOT+SUMOBS(3,J)
2213 CONTINUE
C  CALCULATE EXPECTED VALUES, DEVIATIONS, CHI-SQUARES, PERCENT
      DO 2214 I=1,2
      DO 2214 J=1,2
      SUMEXP(I,J)=SUMOBS(1,3)*SUMOBS(3,J)/SGTOT
      IF(SUMEXP(I,J).LE.0.000) SUMEXP(I,J)=0.01
      SUMDEV(I,J)=SUMOBS(I,J)-SUMEXP(I,J)
      SCHISQ(I,J)=(SUMOBS(I,J)-SUMEXP(I,J))*((SUMOBS(I,J)-SUMEXP(I,J))
      1 /SUMEXP(I,J))
2214 CONTINUE
      DO 2216 I=1,3
      DO 2216 J=1,3
      SOBS(I,J)=SUMOBS(I,J)
      PCNT(I,J)=100.*SOBS(I,J)/SGTOT
2216 CONTINUE
C  WRITE OUT CONTINGENCY TABLE.
      WRITE(6,2250) AMETH
2250 FORMAT('1',3X,'ANALYSIS METHOD',F10.0)
      WRITE(6,2300)
2300 FORMAT('0',5X,'ANALYSIS',28X,'CLINIC RECORD',5X,'PERIOD',6X,
      1'J= 1',9X,'2',9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8',7X,
      2'I',9X,'CSICK010 CSICK100 CSICK200 CSICK300 CSICK400 ',
      3'CSICK600 C WELL TOTALS'/)
      DO 2340 I=1,4
      WRITE(6,2310) I,(OBS(I,J),J=1,8),(E(I,J),J=1,7),(DEV(I,J),J=1,7),
      1 (CHISQ(I,J),J=1,7)
2310 FORMAT(' ',4X,I3,3X,'OBS ',8(F10.2)/5X,'ASICK EXP ',7F10.2/5X,6X,
      1'DEV ',7F10.2/5X,4X,'CHISQ ',7F10.4/)
2340 CONTINUE
      DO 2350 I=5,8
      II=I-4
      WRITE(6,2345) II,(OBS(I,J),J=1,8),(E(I,J),J=1,7),(DEV(I,J),J=1,7),
      1 (CHISQ(I,J),J=1,7)

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2345 FORMAT(' ',4X,I3,3X,'OBS ',8(F10.2)/5X,'AWELL EXP ',7F10.2/5X,6X,
1'DEV ',7F10.2/5X,4X,'CHISQ ',7F10.4/)
2350 CONTINUE
      WRITE(6,2352) (OBS(9,J),J=1,8)
2352 FORMAT(' ',5X,'TOTALS',3X,8(F10.2)//)
      WRITE(6,2355) TCHISQ
2355 FORMAT(' ',10X,'TOTAL CHI SQUARED= ',F10.4//)
      WRITE(6,2356) GTOTAL
2356 FORMAT(' ',10X,'GTOTAL= ',F10.2//)
C  WRITE OUT SUMMARY TABLE.
      WRITE(6,2360) AMETH
2360 FORMAT('1',10X,'ANALYSIS METHOD',F10.0)
      WRITE(6,2400)
2400 FORMAT('0',T10,'J=',T24,'1',T37,'2',T49,'3'/T8,'1',T22,'CSICK',
1T35,'CWEILL',T47,'TOTALS'/T5,'|-----|
2-----|' /T5,'|',T17,'|',T21,'TRUE POS',T30,'|',T33,
3 'FALSE POS',T43,'|',T56,'|')
      I=1
      WRITE(6,2445) I,(PCNT(I,J),J=1,3), (SUMOBS(I,J),J=1,3),
1(SUMEXP(I,J),J=1,2), (SUMDEV(I,J),J=1,2), (SCHISQ(I,J),J=1,2)
2445 FORMAT(' ',T5,'|',I3,T12,'PCNT | ',3(F10.2,' | ')/T5,'|',T13,'OBS
1| ',3(F10.2,' | ')/T5,'| ASICK EXP | ',2(F10.2,' | ')/T5,'|',T56,'|'/
2T5,'|',T13,'DEV | ',2(F10.2,' | ')/T5,'|',T56,'|'/T5,'|',T11,'CHISQ | ',
3 2(F10.2,' | ')/T5,'|',50(' - '),T56,'|'/ T5,'|',T17,'| FAL
4SE NEG | TRUE NEG |',T56,'|')
      I=2
      WRITE(6,2446) I,(PCNT(I,J),J=1,3), (SUMOBS(I,J),J=1,3),
1(SUMEXP(I,J),J=1,2), (SUMDEV(I,J),J=1,2), (SCHISQ(I,J),J=1,2)
2446 FORMAT(' ',T5,'|',I3,T12,'PCNT | ',3(F10.2,' | ')/T5,'|',T13,'OBS
1| ',3(F10.2,' | ')/T5,'| ASICK EXP | ',2(F10.2,' | ')/T5,'|',T56,'|'/
2T5,'|',T13,'DEV | ',2(F10.2,' | ')/T5,'|',T56,'|'/T5,'|',T11,'CHISQ | ',
3 2(F10.2,' | ')/T5,'|',50(' - '),T56,'|')
      WRITE(6,2470) (PCNT(3,J),J=1,3), (SUMOBS(3,J),J=1,3)
2470 FORMAT(' ',T5,'| TOTALS |',T30,'|',T43,'|',T56,'|'/T5,'|',T12,
1 'PCNT | ',3(F10.2,' | ')/T5,'|',T13,'OBS | ',3(F10.2,' | ')/T5,
2 '|',50(' - '),T56,'|')//)
      RETURN
C 1111. RUNNING AVERAGE, 3 DAYS, 90% LIMITS, DAY-TO-DAY.
C 1112. RUNNING AVERAGE, 3 DAYS, 90% LIMITS, 6-DAY PREDICTIVE.
C 1121. RUNNING AVERAGE, 3 DAYS, 1 STD DEV , DAY-TO-DAY.
C 1122. RUNNING AVERAGE, 3 DAYS, 1 STD DEV , 6-DAY PREDICTIVE
C 1132 RUNNING AVERAGE, 3 DAYS, 2 STD DEV, 6-DAY PREDICTIVE.
C
C 1211. RUNNING AVERAGE, 7 DAYS, 90% LIMITS, DAY-TO-DAY.
C 1212. RUNNING AVERAGE, 7 DAYS, 90% LIMITS, 6-DAY PREDICTIVE.
C 1221. RUNNING AVERAGE, 7 DAYS, 1 STD DEV , DAY-TO-DAY.
C 1222. RUNNING AVERAGE, 7 DAYS, 1 STD DEV , 6-DAY PREDICTIVE.
C 1232 RUNNING AVERAGE, 7 DAYS, 2 STD DEV, 6-DAY PREDICTIVE.
C
C 2011. 7-DAY UPDATE AVERAGE, 90% LIMITS, DAY-TO-DAY.
C 2012. 7-DAY UPDATE AVERAGE, 90% LIMITS, 6-DAY PREDICTIVE.
C 2021. 7-DAY UPDATE AVERAGE, 80% LIMITS, DAY-TO-DAY.
C 2022. 7-DAY UPDATE AVERAGE, 80% LIMITS, 6-DAY PREDICTIVE.
C 2031. 7-DAY UPDATE AVERAGE, 1 STD DEV, DAY-TO-DAY.
C 2032. 7-DAY UPDATE AVERAGE, 1 STD DEV, 6-DAY PREDICTIVE.
C 2042 7-DAY UPDATED AVERAGE, 2 STD DEV, 6-DAY PREDICTIVE.
C
C 3011. 36-SUBCLASS REGRESSION COMPARISON, 1 STD DEV , DAY-TO-DAY.
C 3012. 36-SUBCLASS REGRESSION COMPARISON, 1 STD DEV , 6-DAY PREDICTIVE.
C 3021. 36-SUBCLASS REGRESSION COMPARISON, 2 STD DEV , DAY-TO-DAY.
C 3022. 36-SUBCLASS REGRESSION COMPARISON, 2 STD DEV , 6-DAY PREDICTIVE.

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C
C 3411. 3-SUBCLASS REGR, PARITY,THIS WORK, 1 STD DEV, DAY-TO-DAY.
C 3412. 3-SUBCLASS REGR, PARITY,THIS WORK, 1 STD DEV, 6-DAY PREDICTIVE.
C 3421 3-SUBCLASS REGRESSION, 2 STD DEV, DAT-TO-DAY.
C 3422 3-SUBCLASS REGRESSION, 2 STD DEV, 6-DAY PREDICTIVE.
      END
//PLOT.FT03F001 DD UNIT=TAPE,VOL=SER=028632,DSN=CLINCODE,
// DCB=(LRECL=35,RECFM=FB,BLKSIZE=7000),DISP=(OLD,KEEP),
// LABEL=(1,SL,,IN)
//PLOT.SYSIN DD *
      3
      100 3.3740.155.0311
      200 3.7340.160.0487
      300 3.7730.173.0492
```

Table D1. Analysis Method 1111. Running average, 3 days, 90% limits, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.27	2.70	2.97
OBS	130.00	1283.00	1413.00
ASICK EXP	15.38	1397.62	
DEV	114.62	-114.62	
CHISQ	854.51	9.40	
	FALSE NEG	TRUE NEG	
PCNT	0.82	96.22	97.03
OBS	388.00	45802.00	46190.00
AWELL EXP	502.62	45687.37	
DEV	-114.62	114.63	
CHISQ	26.14	0.29	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D2. Analysis Method 1112. Running average, 3 days, 90% limits, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.51	2.45	2.97
OBS	245.00	1168.00	1413.00
ASICK EXP	18.79	1394.21	
DEV	226.21	-226.21	
CHISQ	2723.42	36.70	
	FALSE NEG	TRUE NEG	
PCNT	0.82	96.22	97.03
OBS	388.00	45802.00	46190.00
AWELL EXP	614.21	45575.79	
DEV	-226.21	226.21	
CHISQ	83.31	1.12	
TOTALS			
PCNT	1.33	98.67	100.00
OBS	633.00	46970.00	47603.00

Table D3. Analysis Method 1121. Running average, 3 days, 1 standard deviation, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.39	10.64	11.04
OBS	188.00	5067.00	5255.00
ASICK EXP	57.18	5197.82	
DEV	130.82	-130.82	
CHISQ	299.27	3.29	
	FALSE NEG	TRUE NEG	
PCNT	0.69	88.27	88.96
OBS	330.00	42018.00	42348.00
AWELL EXP	460.82	41887.18	
DEV	-130.82	130.82	
CHISQ	37.14	0.41	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D4. Analysis Method 1122. Running average, 3 days, 1 standard deviation, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	1.11	9.93	11.04
OBS	530.00	4725.00	5255.00
ASICK EXP	94.94	5160.06	
DEV	435.06	-435.06	
CHISQ	1993.73	36.68	
	FALSE NEG	TRUE NEG	
PCNT	0.69	88.27	88.96
OBS	330.00	42018.00	42348.00
AWELL EXP	765.06	41582.93	
DEV	-435.06	435.07	
CHISQ	247.40	4.55	
TOTALS			
PCNT	1.81	98.19	100.00
OBS	860.00	46743.00	47603.00

Table D5. Analysis Method 1132. Running average, 3 days, 2 standard deviations, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.51	1.93	2.44
OBS	241.00	919.00	1160.00
ASICK EXP	15.47	1144.53	
DEV	225.53	-225.53	
CHISQ	3286.98	44.44	
	FALSE NEG	TRUE NEG	
PCNT	0.83	96.74	97.56
OBS	394.00	46049.00	46443.00
AWELL EXP	619.53	45823.47	
DEV	-225.53	225.53	
CHISQ	82.10	1.11	
TOTALS			
PCNT	1.33	98.67	100.00
OBS	635.00	46968.00	47603.00

Table D6. Analysis Method 1211. Running average, 7 days, 90% limits, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.35	4.11	4.46
OBS	168.00	1956.00	2124.00
ASICK EXP	23.11	2100.89	
DEV	144.89	-144.89	
CHISQ	908.26	9.99	
	FALSE NEG	TRUE NEG	
PCNT	0.74	94.80	95.54
OBS	350.00	45129.00	45479.00
AWELL EXP	494.89	44984.11	
DEV	-144.89	144.89	
CHISQ	42.42	0.47	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D7. Analysis Method 1212. Running average, 7 days, 90% limits, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.71	3.75	4.46
OBS	339.00	1785.00	2124.00
ASICK EXP	30.74	2093.26	
DEV	308.26	-308.26	
CHISQ	3090.92	45.39	
	FALSE NEG	TRUE NEG	
PCNT	0.74	94.80	95.54
OBS	350.00	45129.00	45479.00
AWELL EXP	658.26	44820.74	
DEV	-308.26	308.26	
CHISQ	144.35	2.12	
TOTALS			
PCNT	1.45	98.55	100.00
OBS	689.00	46914.00	47603.00

Table D8. Analysis Method 1221. Running average, 7 days, 1 standard deviation, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.47	13.93	14.40
OBS	223.00	6631.00	6584.00
ASICK EXP	74.58	6779.41	
DEV	148.42	-148.41	
CHISQ	295.34	3.25	
	FALSE NEG	TRUE NEG	
PCNT	0.62	84.98	85.60
OBS	295.00	40454.00	40749.00
AWELL EXP	443.42	40305.55	
DEV	-148.42	148.42	
CHISQ	49.68	0.55	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D9. Analysis Method 1222. Running average, 7 days. 1 standard deviation, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	1.40	13.00	14.40
OBS	667.00	6187.00	6854.00
ASICK EXP	138.51	6715.48	
DEV	528.49	-528.48	
CHISQ	2016.45	41.59	
	FALSE NEG	TRUE NEG	
PCNT	0.62	84.98	85.60
OBS	295.00	40454.99	40749.00
AWELL EXP	823.49	39925.51	
DEV	-528.49	528.49	
CHISQ	339.17	7.00	
TOTALS			
PCNT	2.02	97.98	100.00
OBS	962.00	46641.00	47603.00

Table D10. Analysis Method 1232. Running average, 7 days, 2 standard deviations, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.68	2.83	3.51
OBS	324.00	1347.00	1671.00
ASICK EXP	23.80	1647.20	
DEV	300.20	-300.20	
CHISQ	3786.61	54.71	
	FALSE NEG	TRUE NEG	
PCNT	0.74	95.75	96.49
OBS	354.00	45578.00	45932.00
AWELL EXP	654.20	45277.80	
DEV	-300.20	300.20	
CHISQ	137.76	1.99	
TOTALS			
PCNT	1.42	98.58	100.00
OBS	678.00	46925.00	47603.00

Table D11. Analysis Method 2011. 7-day update average, 90% limits, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.42	7.25	7.66
OBS	198.00	3449.00	3647.00
ASICK EXP	39.69	3607.31	
DEV	158.31	-158.31	
CHISQ	631.55	6.95	
	FALSE NEG	TRUE NEG	
PCNT	0.67	91.67	92.34
OBS	320.00	43636.00	43956.00
AWELL EXP	478.31	43477.68	
DEV	-158.31	158.32	
CHISQ	52.40	0.58	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D12. Analysis Method 2012. 7-day update average, 80% limits, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.94	6.72	7.66
OBS	446.00	3201.00	3647.00
ASICK EXP	58.69	3588.31	
DEV	387.31	-387.31	
CHISQ	2556.21	41.81	
	FALSE NEG	TRUE NEG	
PCNT	0.67	91.67	92.34
OBS	320.00	43636.00	43956.00
AWELL EXP	707.31	43248.68	
DEV	-387.31	387.32	
CHISQ	212.09	3.47	
TOTALS			
PCNT	1.61	98.39	100.00
OBS	766.00	46837.00	47603.00

Table D13. Analysis Method 2021. 7-day update average, 80% limits, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.23	1.22	1.45
OBS	109.00	581.00	690.00
ASICK EXP	7.51	682.49	
DEV	101.49	-101.49	
CHISQ	1371.88	15.09	
	FALSE NEG	TRUE NEG	
PCNT	0.86	97.69	98.55
OBS	409.00	46504.00	46913.00
AWELL EXP	510.49	46402.50	
DEV	-101.49	101.50	
CHISQ	20.18	0.22	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D14. Analysis Method 2022. 7-day update average, 80% limits, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.35	1.10	1.45
OBS	168.00	522.00	690.00
ASICK EXP	8.36	681.64	
DEV	159.64	-159.64	
CHISQ	3047.01	37.39	
	FALSE NEG	TRUE NEG	
PCNT	0.86	97.69	98.55
OBS	409.00	46504.00	46913.00
AWELL EXP	568.64	46344.36	
DEV	-159.64	159.64	
CHISQ	44.82	0.55	
TOTALS			
PCNT	1.21	98.79	100.00
OBS	577.00	47026.00	47603.00

Table D15. Analysis Method 2031. 7-day update average, 1 standard deviation, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.55	20.21	20.76
OBS	262.00	9620.00	9882.00
ASICK EXP	107.53	9774.46	
DEV	154.47	-154.46	
CHISQ	221.89	2.44	
	FALSE NEG	TRUE NEG	
PCNT	0.54	78.70	79.24
OBS	256.00	37465.00	37721.00
AWELL EXP	410.47	37310.53	
DEV	-154.47	154.47	
CHISQ	58.13	0.64	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D16. Analysis Method 2032. 7-day update average, 1 standard deviation, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	1.77	18.99	20.76
OBS	843.00	9039.00	9882.00
ASICK EXP	228.14	9653.86	
DEV	614.86	-614.86	
CHISQ	1657.06	39.16	
	FALSE NEG	TRUE NEG	
PCNT	0.54	78.70	79.24
OBS	256.00	37465.00	37721.00
AWELL EXP	870.86	36850.14	
DEV	-614.86	614.86	
CHISQ	434.11	10.26	
TOTALS			
PCNT	2.31	97.69	100.00
OBS	1099.00	46504.00	47603.00

Table D17. Analysis Method 2042. 7-day updated average, 2 standard deviations, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.95	5.30	6.25
OBS	453.00	2521.00	2974.00
ASICK EXP	48.42	2925.58	
DEV	404.58	-404.58	
CHISQ	3380.68	55.95	
	FALSE NEG	TRUE NEG	
PCNT	0.68	93.08	93.75
OBS	322.00	44307.00	44629.00
AWELL EXP	726.58	43902.41	
DEV	-404.58	404.59	
CHISQ	225.28	3.73	
TOTALS			
PCNT	1.63	98.37	100.00
OBS	775.00	46828.00	47603.00

Table D18. Analysis Method 3011. 36-subclass regression comparison, 1 standard deviation, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.46	14.05	14.51
OBS	218.00	6687.00	6905.00
ASICK EXP	75.14	6829.86	
DEV	142.86	-142.86	
CHISQ	271.63	2.99	
	FALSE NEG	TRUE NEG	
PCNT	0.63	84.86	85.49
OBS	300.00	40398.00	40698.00
AWELL EXP	442.86	40255.13	
DEV	-142.86	142.87	
CHISQ	46.09	0.51	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D19. Analysis Method 3012. 36-subclass regression comparison,
1 standard deviation, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	1.35	13.16	14.51
OBS	641.00	6264.00	6905.00
ASICK EXP	136.50	6768.50	
DEV	504.50	-504.50	
CHISQ	1864.71	37.60	
	FALSE NEG	TRUE NEG	
PCNT	0.63	84.86	85.49
OBS	300.00	40398.00	40698.00
AWELL EXP	804.50	39893.49	
DEV	-504.50	504.51	
CHISQ	316.37	6.38	
TOTALS			
PCNT	1.98	98.02	100.00
OBS	941.00	46662.00	47603.00

Table D20. Analysis Method 3021. 36-subclass regression comparison,
2 standard deviations, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.38	5.46	5.83
OBS	180.00	2597.00	2777.00
ASICK EXP	30.22	2746.78	
DEV	149.78	-149.78	
CHISQ	742.41	8.17	
	FALSE NEG	TRUE NEG	
PCNT	0.71	93.46	94.17
OBS	338.00	44488.00	44826.00
AWELL EXP	487.78	44338.21	
DEV	-149.78	149.79	
CHISQ	45.99	0.51	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D21. Analysis Method 3022. 36-subclass regression comparison,
2 standard deviations, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.85	4.98	5.83
OBS	405.00	2372.00	2777.00
ASICK EXP	43.34	2733.66	
DEV	361.66	-361.66	
CHISQ	3017.59	47.85	
	FALSE NEG	TRUE NEG	
PCNT	0.71	93.46	94.17
OBS	338.00	44488.00	44826.00
AWELL EXP	699.66	44126.34	
DEV	-361.66	361.66	
CHISQ	186.94	2.96	
TOTALS			
PCNT	1.56	98.44	100.00
OBS	743.00	46860.00	47603.00

Table D22. Analysis Method 3411. 3-subclass regression comparison,
1 standard deviation, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.45	14.08	14.53
OBS	214.00	6701.00	6915.00
ASICK EXP	75.25	6839.75	
DEV	138.75	-138.75	
CHISQ	255.86	2.81	
	FALSE NEG	TRUE NEG	
PCNT	0.64	84.83	85.47
OBS	304.00	43384.00	40688.00
AWELL EXP	442.75	40245.24	
DEV	-138.75	138.76	
CHISQ	43.48	0.48	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D23. Analysis Method 3412. 3-subclass regression comparison,
1 standard deviation, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	1.38	13.15	14.53
OBS	655.00	6260.00	6915.00
ASICK EXP	139.31	6775.69	
DEV	515.69	-515.69	
CHISQ	1908.99	39.25	
	FALSE NEG	TRUE NEG	
PCNT	0.64	84.83	85.47
OBS	304.00	40384.00	40688.00
AWELL EXP	819.69	39868.30	
DEV	-515.69	515.70	
CHISQ	324.44	6.67	
TOTALS			
PCNT	2.01	97.99	100.00
OBS	959.00	46644.00	47603.00

Table D24. Analysis Method 3421. 3-subclass regression, 2 standard
deviations, day-to-day.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.38	5.22	5.60
OBS	183.00	2484.00	2667.00
ASICK EXP	29.02	2637.98	
DEV	153.98	-153.98	
CHISQ	816.96	8.99	
	FALSE NEG	TRUE NEG	
PCNT	0.70	93.69	94.40
OBS	335.00	44601.00	44936.00
AWELL EXP	488.98	44447.02	
DEV	-153.98	153.98	
CHISQ	48.49	0.53	
TOTALS			
PCNT	1.09	98.91	100.00
OBS	518.00	47085.00	47603.00

Table D25. Analysis Method 3422. 3-subclass regression, 2 standard deviations, 6-day predictive.

	CSICK	CWELL	TOTALS
	TRUE POS	FALSE POS	
PCNT	0.87	4.73	5.60
OBS	413.00	2254.00	2667.00
ASICK EXP	41.91	2625.09	
DEV	371.09	-371.09	
CHISQ	3286.05	52.46	
	FALSE NEG	TRUE NEG	
PCNT	0.70	93.69	94.40
OBS	335.00	44601.00	44936.00
AWELL EXP	706.09	44229.90	
DEV	-371.09	371.10	
CHISQ	195.03	3.11	
TOTALS			
PCNT	1.57	98.43	100.00
OBS	748.00	46855.00	47603.00

Table D26. Analysis Method 1111. Running average, 3 days, 90% limits, day-to-day.

ANALYSIS PERIOD		CLINIC RECORD						TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	3.00	23.00	0.0	20.00	1.00	0.0	228.00
ASICK	EXP	0.10	1.36	0.51	0.60	0.35	0.08	272.01
	DEV	2.90	21.64	-0.51	19.40	0.65	-0.08	-44.01
	CHISQ	80.6549	343.3750	0.5084	632.8345	1.2316	0.0751	7.1198
2	OBS	1.00	16.00	0.0	9.00	0.0	1.00	277.00
ASICK	EXP	0.11	1.51	0.56	0.66	0.38	0.08	300.69
	DEV	0.89	14.49	-0.56	8.34	-0.38	0.92	-23.69
	CHISQ	6.8143	139.3662	0.5620	105.8004	0.3832	10.1283	1.8667
3	OBS	3.00	23.00	3.00	10.00	1.00	2.00	311.00
ASICK	EXP	0.13	1.75	0.65	0.76	0.44	0.10	349.16
	DEV	2.87	21.25	2.35	9.24	0.56	1.90	-38.16
	CHISQ	61.5598	258.0256	8.4443	111.6887	0.6925	37.5895	4.1703
4	OBS	1.00	4.00	1.00	7.00	1.00	0.0	467.00
ASICK	EXP	0.18	2.38	0.89	1.04	0.61	0.13	475.77
	DEV	0.82	1.62	0.11	5.96	0.39	-0.13	-8.77
	CHISQ	3.6800	1.0942	0.0138	34.1220	0.2557	0.1314	0.1615
1	OBS	6.00	63.00	33.00	34.00	24.00	1.00	11564.00
AWELL	EXP	4.43	58.13	21.68	25.37	14.78	3.20	11597.41
	DEV	1.57	4.87	11.32	8.63	9.22	-2.20	-33.41
	CHISQ	0.5535	0.4082	5.9171	2.9359	5.7541	1.5143	0.0962
2	OBS	3.00	43.00	23.00	12.00	12.00	5.00	11598.00
AWELL	EXP	4.42	57.98	21.62	25.31	14.74	3.19	11568.72
	DEV	-1.42	-14.98	1.38	-13.31	-2.74	1.81	29.28
	CHISQ	0.4576	3.8725	0.0879	6.9971	0.5100	1.0211	0.0741
3	OBS	0.0	40.00	18.00	7.00	14.00	4.00	11560.00
AWELL	EXP	4.40	57.72	21.52	25.19	14.68	3.18	11516.30
	DEV	-4.40	-17.72	-3.52	-18.19	-0.68	0.82	43.70
	CHISQ	4.4025	5.4411	0.5768	13.1373	0.0311	0.2117	0.1658
4	OBS	1.00	24.00	10.00	4.00	7.00	0.0	11080.00
AWELL	EXP	4.21	55.16	20.57	24.07	14.02	3.04	11004.93
	DEV	-3.21	-31.16	-10.57	-20.07	-7.02	-3.04	75.07
	CHISQ	2.4447	17.6016	5.4297	16.7383	3.5176	3.0384	0.5121
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47085.00

47603.00
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Table D27. Analysis Method 1112. Running average, 3 days, 90% limits, 6-day predictive.

ANALYSIS PERIOD		CLINIC RECORD						TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	6.00	35.00	6.00	31.00	4.00	0.00	275.00
	ASICK EXP	0.17	1.64	0.58	0.77	0.40	0.08	271.34
	DEV	5.83	33.36	5.42	30.23	3.60	-0.08	-78.34
	CHISQ	195.8955	678.2944	50.2831	1180.1973	31.9705	0.0809	22.6194
2	OBS	2.00	34.00	3.00	18.00	1.00	1.00	304.00
	ASICK EXP	0.19	1.81	0.65	0.86	0.45	0.09	299.96
	DEV	1.81	32.19	2.35	17.14	0.55	0.91	-54.96
	CHISQ	17.0701	571.1960	8.5985	343.4727	0.6840	9.2743	10.0692
3	OBS	9.00	35.00	6.00	19.00	5.00	3.00	353.00
	ASICK EXP	0.22	2.11	0.75	0.99	0.52	0.10	348.31
	DEV	8.78	32.89	5.25	18.01	4.48	2.90	-72.31
	CHISQ	346.3247	513.7769	36.8152	326.2903	38.6808	80.7948	15.0102
4	OBS	3.00	10.00	2.00	9.00	3.00	0.0	481.00
	ASICK EXP	0.30	2.87	1.02	1.35	0.71	0.14	474.60
	DEV	2.70	7.13	0.98	7.65	2.29	-0.14	-20.60
	CHISQ	23.9931	17.7171	0.9400	43.1772	7.4316	0.1415	0.8944
1	OBS	6.00	63.00	33.00	34.00	24.00	1.00	11725.00
	AWELL EXP	7.39	69.95	24.88	33.01	17.24	3.45	11569.08
	DEV	-1.39	-6.95	8.12	0.99	6.76	-2.45	-5.08
	CHISQ	0.2612	0.6908	2.6523	0.0300	2.6492	1.7383	0.0022
2	OBS	3.00	43.00	23.00	12.00	12.00	5.00	11696.00
	AWELL EXP	7.37	69.78	24.82	32.92	17.20	3.44	11540.46
	DEV	-4.37	-26.78	-1.82	-20.92	-5.20	1.56	57.54
	CHISQ	2.5920	10.2766	0.1328	13.2974	1.5715	0.7077	0.2868
3	OBS	0.0	40.00	18.00	7.00	14.00	4.00	11643.00
	AWELL EXP	7.34	69.46	24.70	32.77	17.12	3.42	11488.17
	DEV	-7.34	-29.46	-6.70	-25.77	-3.12	0.58	71.83
	CHISQ	7.3376	12.4963	1.8189	20.2695	0.5689	0.0968	0.4491
4	OBS	1.00	24.00	10.00	4.00	7.00	0.0	11126.00
	AWELL EXP	7.01	66.38	23.61	31.32	16.36	3.27	10978.05
	DEV	-6.01	-42.38	-13.61	-27.32	-9.36	-3.27	101.95
	CHISQ	5.1544	27.0554	7.8424	23.8300	5.3557	3.2721	0.9468
TOTALS		30.00	284.00	101.00	134.00	70.00	14.00	46970.00
								47603.00

Table D28. Analysis Method 1121. Running average, 3 days, 1 standard deviation, day-to-day.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	6.00	34.00	3.00	26.00	7.00	1.00	947.00
ASICK	EXP	0.39	5.08	1.89	2.22	1.29	0.28	1012.86
	DEV	5.61	28.92	1.11	23.78	5.71	0.72	-65.86
	CHISQ	81.3618	164.7856	0.6474	255.3166	25.2553	1.8556	4.2821
2	OBS	1.00	17.00	3.00	11.00	2.00	3.00	1447.00
ASICK	EXP	0.56	7.36	2.74	3.21	1.87	0.41	1467.85
	DEV	0.44	9.64	0.26	7.79	0.13	2.59	-20.85
	CHISQ	0.3432	12.6385	0.0240	18.8942	0.0090	16.6127	0.2962
3	OBS	3.00	29.00	5.00	11.00	3.00	2.00	1284.00
ASICK	EXP	0.51	6.63	2.47	2.89	1.69	0.37	1322.45
	DEV	2.49	22.37	2.53	8.11	1.31	1.63	-38.45
	CHISQ	12.3077	75.5065	2.5865	22.7194	1.0258	7.3203	1.1180
4	OBS	2.00	7.00	3.00	8.00	1.00	0.0	1389.00
ASICK	EXP	0.53	6.99	2.61	3.05	1.78	0.39	1394.66
	DEV	1.47	0.01	0.39	4.95	-0.78	-0.39	-5.66
	CHISQ	4.0356	0.0000	0.0594	8.0286	0.3399	0.3851	0.0229
1	OBS	3.00	52.00	30.00	28.00	18.00	0.0	10845.00
AWELL	EXP	4.15	54.42	20.29	23.75	13.83	3.00	10856.56
	DEV	-1.15	-2.42	9.71	4.25	4.17	-3.00	-11.56
	CHISQ	0.3188	0.1072	4.6463	0.7609	1.2543	2.9975	0.0123
2	OBS	3.00	42.00	20.00	10.00	10.00	3.00	10428.00
AWELL	EXP	3.98	52.13	19.44	22.75	13.25	2.87	10401.56
	DEV	-0.98	-10.13	0.56	-12.75	-3.25	0.13	26.44
	CHISQ	0.2397	1.9702	0.0161	7.1486	0.7992	0.0057	0.0672
3	OBS	0.0	34.00	16.00	6.00	12.00	4.00	10587.00
AWELL	EXP	4.03	52.84	19.70	23.06	13.43	2.91	10543.00
	DEV	-4.03	-18.84	-3.70	-17.06	-1.43	1.09	44.00
	CHISQ	4.0305	6.7196	0.6964	12.6241	0.1532	0.4075	0.1836
4	OBS	0.0	21.00	8.00	3.00	7.00	0.0	10158.00
AWELL	EXP	3.86	50.55	18.85	22.06	12.85	2.78	10086.04
	DEV	-3.86	-29.55	-10.85	-19.06	-5.85	-2.78	71.96
	CHISQ	3.8558	17.2768	6.2456	16.4714	2.6650	2.7847	0.5135
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47085.00
								47603.00

Table D29. Analysis Method 1122. Running average, 3 days, 1 standard deviation, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	11.00	68.00	15.00	55.00	25.00	4.00	1024.00
	ASICK EXP	0.77	7.96	3.14	3.87	2.30	0.45	1005.50
	DEV	10.23	60.04	11.86	51.13	22.70	3.55	-159.50
	CHISQ	135.0234	452.9246	44.7820	675.1169	223.8395	27.8706	25.3011
2	OBS	3.00	53.00	23.00	39.00	13.00	7.00	1484.00
	ASICK EXP	1.12	11.53	4.55	5.61	3.34	0.65	1457.19
	DEV	1.88	41.47	18.45	33.39	9.66	6.35	-111.19
	CHISQ	3.1417	149.0634	74.7774	198.6661	28.0001	61.5021	8.4842
3	OBS	12.00	69.00	21.00	26.00	17.00	3.00	1337.00
	ASICK EXP	1.01	10.39	4.10	5.06	3.01	0.59	1312.85
	DEV	10.99	58.61	16.90	20.94	13.99	2.41	-123.85
	CHISQ	119.4285	330.5330	69.6452	86.7695	65.1703	9.8488	11.6827
4	OBS	4.00	31.00	13.00	13.00	5.00	0.0	1410.00
	ASICK EXP	1.07	10.96	4.32	5.33	3.17	0.62	1384.53
	DEV	2.93	20.04	8.68	7.67	1.83	-0.62	-40.53
	CHISQ	8.0712	36.6467	17.4040	11.0294	1.0574	0.6220	1.1862
1	OBS	3.00	52.00	30.00	28.00	18.00	0.0	10976.00
	AWELL EXP	8.30	85.31	33.66	41.50	24.67	4.84	10777.70
	DEV	-5.30	-33.31	-3.66	-13.50	-6.67	-4.84	67.30
	CHISQ	3.3849	13.0076	0.3987	4.3933	1.8040	4.8420	0.4202
2	OBS	3.00	42.00	20.00	10.00	10.00	3.00	10516.00
	AWELL EXP	7.95	81.74	32.25	39.76	23.64	4.64	10326.01
	DEV	-4.95	-39.74	-12.25	-29.76	-13.64	-1.64	101.99
	CHISQ	3.0845	19.3183	4.6549	22.2787	7.8680	0.5791	1.0073
3	OBS	0.0	34.00	16.00	6.00	12.00	4.00	10659.00
	AWELL EXP	8.06	82.85	32.69	40.30	23.96	4.70	10466.43
	DEV	-8.06	-48.85	-16.69	-34.30	-11.96	-0.70	120.57
	CHISQ	8.0609	28.8015	8.5223	29.1978	5.9692	0.1049	1.3889
4	OBS	0.0	21.00	8.00	3.00	7.00	0.0	10197.00
	AWELL EXP	7.71	79.26	31.27	38.56	22.92	4.50	10012.77
	DEV	-7.71	-58.26	-23.27	-35.56	-15.92	-4.50	145.23
	CHISQ	7.7115	42.8215	17.3209	32.7910	11.0582	4.4984	2.1064
TOTALS		36.00	370.00	146.00	180.00	107.00	21.00	47603.00

Table D30. Analysis Method 1132. Running average, 3 days, 2 standard deviations, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	6.00	35.00	4.00	26.00	5.00	0.00	226.00
ASICK	EXP	0.14	1.37	0.49	0.62	0.33	0.06	222.99
	DEV	5.86	33.63	3.51	25.38	4.67	-0.06	-72.99
	CHISQ	249.6128	824.1919	25.2086	1035.5500	65.5583	0.0617	23.8888
2	OBS	2.00	34.00	7.00	17.00	2.00	1.00	351.00
ASICK	EXP	0.21	2.13	0.76	0.97	0.52	0.10	346.32
	DEV	1.79	31.87	6.24	16.03	1.48	0.90	-58.32
	CHISQ	14.9202	476.6147	51.2782	266.1602	4.2659	8.5282	9.8203
3	OBS	6.00	38.00	6.00	18.00	3.00	2.00	307.00
ASICK	EXP	0.19	1.86	0.66	0.84	0.45	0.08	302.90
	DEV	5.81	36.14	5.34	17.16	2.55	1.92	-68.90
	CHISQ	180.6736	700.6204	42.8595	348.3481	14.3875	43.7942	15.6744
4	OBS	4.00	10.00	3.00	10.00	2.00	0.0	276.00
ASICK	EXP	0.17	1.68	0.60	0.76	0.41	0.08	272.32
	DEV	3.83	8.32	2.40	9.24	1.59	-0.08	-25.32
	CHISQ	87.3265	41.3554	9.6678	112.4196	6.2615	0.0754	2.3539
1	OBS	6.00	64.00	33.00	36.00	24.00	1.00	11774.00
AWELL	EXP	7.17	71.48	25.48	32.40	17.31	3.22	11616.94
	DEV	-1.17	-7.48	7.52	3.60	6.69	-2.22	-6.94
	CHISQ	0.1918	0.7828	2.2223	0.3997	2.5822	1.5264	0.0041
2	OBS	3.00	45.00	22.00	12.00	12.00	5.00	11649.00
AWELL	EXP	7.10	70.72	25.21	32.06	17.13	3.18	11493.61
	DEV	-4.10	-25.72	-3.21	-20.06	-5.13	1.82	56.39
	CHISQ	2.3648	9.3550	0.4076	12.5492	1.5362	1.0398	0.2767
3	OBS	2.00	39.00	18.00	8.00	14.00	4.00	11689.00
AWELL	EXP	7.12	70.96	25.29	32.17	17.19	3.19	11533.07
	DEV	-5.12	-31.96	-7.29	-24.17	-3.19	0.81	70.93
	CHISQ	3.6827	14.3977	2.1023	18.1569	0.5915	0.2044	0.4362
4	OBS	0.0	24.00	10.00	4.00	8.00	0.0	11331.00
AWELL	EXP	6.90	68.79	24.52	31.18	16.66	3.09	11179.85
	DEV	-6.90	-44.79	-14.52	-27.18	-8.66	-3.09	105.15
	CHISQ	6.9020	29.1642	8.5960	23.6952	4.5032	3.0944	0.9890
TOTALS		29.00	289.00	103.00	131.00	70.00	13.00	47603.00

Table D31. Analysis Method 1211. Running average, 7 days, 90% limits, day-to-day.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	3.00	34.00	1.00	24.00	2.00	0.0	281.00
ASICK	EXP	0.13	1.71	0.64	0.75	0.43	0.09	341.25
	DEV	2.87	32.29	0.36	23.25	1.57	-0.09	-60.25
	CHISQ	63.1203	609.5769	0.2057	724.3606	5.6335	0.0942	10.6361
2	OBS	1.00	23.00	0.0	10.00	0.0	1.00	406.00
ASICK	EXP	0.17	2.19	0.82	0.95	0.56	0.12	436.20
	DEV	0.83	20.81	-0.82	9.05	-0.56	0.88	-30.20
	CHISQ	4.1636	198.1438	0.8152	85.7535	0.5558	6.4238	2.0910
3	OBS	3.00	27.00	3.00	12.00	2.00	2.00	455.00
ASICK	EXP	0.19	2.50	0.93	1.09	0.64	0.14	498.52
	DEV	2.81	24.50	2.07	10.91	1.36	1.86	-43.52
	CHISQ	41.4158	240.2542	4.5914	109.1377	2.9319	25.1993	3.7985
4	OBS	2.00	7.00	2.00	8.00	1.00	0.0	814.00
ASICK	EXP	0.32	4.13	1.54	1.80	1.05	0.23	824.92
	DEV	1.68	2.87	0.46	6.20	-0.05	-0.23	-10.92
	CHISQ	8.9993	1.9856	0.1362	21.2705	0.0025	0.2278	0.1447
1	OBS	6.00	52.00	32.00	30.00	23.00	1.00	11511.00
AWELL	EXP	4.41	57.78	21.55	25.22	14.69	3.18	11528.17
	DEV	1.59	-5.78	10.45	4.78	8.31	-2.18	-17.17
	CHISQ	0.5758	0.5785	5.0726	0.9067	4.7005	1.4971	0.0256
2	OBS	3.00	36.00	23.00	11.00	12.00	5.00	11469.00
AWELL	EXP	4.37	57.31	21.37	25.01	14.57	3.16	11433.21
	DEV	-1.37	-21.31	1.63	-14.01	-2.57	1.84	35.79
	CHISQ	0.4299	7.9213	0.1246	7.8485	0.4531	1.0764	0.1120
3	OBS	0.0	36.00	18.00	5.00	13.00	4.00	11416.00
AWELL	EXP	4.35	56.97	21.24	24.87	14.48	3.14	11366.95
	DEV	-4.35	-20.97	-3.24	-19.87	-1.48	0.86	49.05
	CHISQ	4.3454	7.7209	0.4955	15.8710	0.1522	0.2366	0.2117
4	OBS	0.0	21.00	9.00	3.00	7.00	0.0	10733.00
AWELL	EXP	4.07	53.41	19.92	23.31	13.58	2.94	10655.77
	DEV	-4.07	-32.41	-10.92	-20.31	-6.58	-2.94	77.23
	CHISQ	4.0736	19.6660	5.9824	17.6959	3.1872	2.9420	0.5598
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47085.00
								47603.00

Table D32. Analysis Method 1212. Running average, 7 days, 90% limits, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	6.00	53.00	8.00	32.00	8.00	0.0	238.00
ASICK	EXP	0.23	2.26	0.80	1.01	0.58	0.11	340.01
	DEV	5.77	50.74	7.20	30.99	7.42	-0.11	-102.01
	CHISQ	143.4590	1138.5200	64.3603	953.4910	94.9635	0.1087	30.6032
2	OBS	2.00	47.00	7.00	22.00	2.00	2.00	359.00
ASICK	EXP	0.30	2.89	1.03	1.29	0.74	0.14	434.62
	DEV	1.70	44.11	5.97	20.71	1.26	1.86	-75.62
	CHISQ	9.7894	673.1426	34.6790	333.1477	2.1383	24.9238	13.1562
3	OBS	11.00	47.00	6.00	22.00	12.00	3.00	403.00
ASICK	EXP	0.34	3.30	1.18	1.47	0.85	0.16	496.71
	DEV	10.66	43.70	4.82	20.53	11.15	2.84	-93.71
	CHISQ	335.4792	578.0239	19.8078	286.3491	146.8577	50.8291	17.6778
4	OBS	4.00	20.00	8.00	14.00	3.00	0.0	785.00
ASICK	EXP	0.56	5.47	1.94	2.44	1.40	0.26	821.93
	DEV	3.44	14.53	6.06	11.56	1.60	-0.26	-36.93
	CHISQ	21.0996	38.6431	18.8545	54.9193	1.8229	0.2628	1.6592
1	OBS	6.00	52.00	32.00	30.00	23.00	1.00	11511.00
AWELL	EXP	7.83	76.39	27.18	34.03	19.59	3.67	11486.30
	DEV	-1.83	-24.39	4.82	-4.03	3.41	-2.67	24.70
	CHISQ	0.4297	7.7869	0.8559	0.4778	0.5947	1.9449	0.0531
2	OBS	3.00	36.00	23.00	11.00	12.00	5.00	11469.00
AWELL	EXP	7.77	75.76	26.95	33.75	19.43	3.64	11391.70
	DEV	-4.77	-39.76	-3.95	-22.75	-7.43	1.36	77.30
	CHISQ	2.9285	20.8667	0.5798	15.3370	2.8385	0.5061	0.5246
3	OBS	0.0	36.00	18.00	5.00	13.00	4.00	11416.00
AWELL	EXP	7.73	75.32	26.80	33.56	19.31	3.62	11325.66
	DEV	-7.73	-39.32	-8.80	-28.56	-6.31	0.38	90.34
	CHISQ	7.7252	20.5273	2.8878	24.3014	2.0636	0.0396	0.7206
4	OBS	0.0	21.00	9.00	3.00	7.00	0.0	10733.00
AWELL	EXP	7.24	70.61	25.12	31.46	18.10	3.39	10617.07
	DEV	-7.24	-49.61	-16.12	-28.46	-11.10	-3.39	115.93
	CHISQ	7.2419	34.8542	10.3448	25.7431	6.8112	3.3946	1.2659
TOTALS		32.00	312.00	111.00	139.00	80.00	15.00	46914.00
								47603.00

Table D33. Analysis Method 1221. Running average, 7 days, 1 standard deviation, day-to-day.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1 OBS		5.00	42.00	3.00	29.00	5.00	1.00	1112.00
ASICK EXP		0.42	5.51	2.06	2.41	1.40	0.30	
DEV		4.58	36.49	0.94	26.59	3.60	0.70	
CHISQ		49.8766	241.4879	0.4338	293.9390	9.2384	1.5966	
2 OBS		1.00	26.00	4.00	13.00	3.00	3.00	1964.00
ASICK EXP		0.74	9.74	3.63	4.25	2.48	0.54	
DEV		0.26	16.26	0.37	8.75	0.52	2.46	
CHISQ		0.0892	27.1637	0.0376	18.0183	0.1111	11.3163	
3 OBS		3.00	35.00	6.00	12.00	5.00	2.00	1717.00
ASICK EXP		0.65	8.51	3.17	3.72	2.16	0.47	
DEV		2.35	26.49	2.83	8.28	2.84	1.53	
CHISQ		8.5115	82.4213	2.5159	18.4756	3.7160	4.9995	
4 OBS		2.00	10.00	2.00	9.00	2.00	0.0	2061.00
ASICK EXP		0.78	10.22	3.81	4.46	2.60	0.56	
DEV		1.22	-0.22	-1.81	4.54	-0.60	-0.56	
CHISQ		1.9120	0.0046	0.8599	4.6231	0.1375	0.5628	
1 OBS		4.00	44.00	30.00	25.00	20.00	0.0	10888.00
AWELL EXP		4.12	53.98	20.13	23.56	13.72	2.97	
DEV		-0.12	-9.98	9.87	1.44	6.28	-2.97	
CHISQ		0.0033	1.8448	4.8421	0.0882	2.8706	2.9734	
2 OBS		3.00	33.00	19.00	8.00	9.00	3.00	10036.00
AWELL EXP		3.79	49.76	18.55	21.72	12.65	2.74	
DEV		-0.79	-16.76	0.45	-13.72	-3.65	0.26	
CHISQ		0.1665	5.6423	0.0108	8.6624	1.0530	0.0245	
3 OBS		0.0	28.00	15.00	5.00	10.00	4.00	10279.00
AWELL EXP		3.89	50.96	19.00	22.24	12.96	2.81	
DEV		-3.89	-22.96	-4.00	-17.24	-2.96	1.19	
CHISQ		3.8868	10.3445	0.8429	13.3650	0.6744	0.5069	
4 OBS		0.0	18.00	9.00	2.00	6.00	0.0	9546.00
AWELL EXP		3.61	47.33	17.65	20.65	12.03	2.61	
DEV		-3.61	-29.33	-8.65	-18.65	-6.03	-2.61	
CHISQ		3.6096	18.1720	4.2370	16.8486	3.0240	2.6069	
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47603.00

Table D34. Analysis Method 1222. Running average, 7 days, 1 standard deviation, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1 OBS		12.00	82.00	17.00	56.00	30.00	4.00	1112.00
ASICK EXP		0.89	9.51	3.88	4.67	2.87	0.65	1089.53
DEV		11.11	72.49	13.12	51.33	27.13	3.35	-178.53
CHISQ		139.1092	552.7405	44.4057	563.9082	256.1055	17.1160	29.2531
2 OBS		3.00	78.00	34.00	51.00	17.00	12.00	1964.00
ASICK EXP		1.57	16.79	6.85	8.25	5.07	1.16	1924.31
DEV		1.43	61.21	27.15	42.75	11.93	10.84	-155.31
CHISQ		1.3083	223.1082	107.6372	221.4639	28.0237	101.8067	12.5349
3 OBS		12.00	87.00	25.00	32.00	23.00	5.00	1717.00
ASICK EXP		1.37	14.68	5.99	7.21	4.44	1.01	1682.30
DEV		10.63	72.32	19.01	24.79	18.56	3.99	-149.30
CHISQ		82.4320	356.2744	60.3719	85.1633	77.6744	15.7640	13.2502
4 OBS		4.00	37.00	17.00	21.00	8.00	0.0	2061.00
ASICK EXP		1.65	17.62	7.19	8.66	5.33	1.21	2019.35
DEV		2.35	19.38	9.81	12.34	2.67	-1.21	-45.35
CHISQ		3.3703	21.3114	13.3982	17.5881	1.3433	1.2123	1.0184
1 OBS		4.00	44.00	30.00	25.00	20.00	0.0	10888.00
AWELL EXP		8.69	93.09	37.97	45.75	28.13	6.40	10667.96
DEV		-4.69	-49.09	-7.97	-20.75	-8.13	-6.40	97.04
CHISQ		2.5324	25.8879	1.6723	9.4077	2.3513	6.4043	0.8826
2 OBS		3.00	33.00	19.00	8.00	9.00	3.00	10036.00
AWELL EXP		8.01	85.81	35.00	42.17	25.93	5.90	9833.18
DEV		-5.01	-52.81	-16.00	-34.17	-16.93	-2.90	127.82
CHISQ		3.1348	32.4979	7.3124	27.6832	11.0553	1.4278	1.6616
3 OBS		0.0	28.00	15.00	5.00	10.00	4.00	10279.00
AWELL EXP		8.21	87.88	35.84	43.19	26.56	6.05	10071.27
DEV		-8.21	-59.88	-20.84	-38.19	-16.56	-2.05	145.73
CHISQ		8.2054	40.8050	12.1217	33.7652	10.3247	0.6924	2.1087
4 OBS		0.0	18.00	9.00	2.00	6.00	0.0	9546.00
AWELL EXP		7.62	81.62	33.29	40.11	24.67	5.61	9353.08
DEV		-7.62	-63.62	-24.29	-38.11	-18.67	-5.61	157.92
CHISQ		7.6203	49.5869	17.7218	36.2064	14.1251	5.6149	2.6663
TOTALS		38.00	407.00	166.00	200.00	123.00	28.00	47603.00

Table D35. Analysis Method 1232. Running average, 7 days, 2 standard deviations, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1 OBS		7.00	47.00	8.00	29.00	10.00	0.0	284.00
ASICK EXP		0.19	1.86	0.64	0.81	0.46	0.08	279.95
DEV		6.81	45.14	7.36	28.19	9.54	-0.08	-96.95
CHISQ		242.8532	1094.6052	83.9724	979.3196	198.1427	0.0776	33.5777
2 OBS		2.00	52.00	8.00	20.00	2.00	1.00	501.00
ASICK EXP		0.34	3.28	1.14	1.43	0.81	0.14	493.86
DEV		1.66	48.72	6.86	18.57	1.19	0.86	-77.86
CHISQ		8.2138	722.7554	41.4424	240.8897	1.7463	5.4457	12.2763
3 OBS		11.00	51.00	5.00	21.00	7.00	2.00	447.00
ASICK EXP		0.30	2.93	1.01	1.28	0.72	0.12	440.63
DEV		10.70	48.07	3.99	19.72	6.28	1.88	-90.63
CHISQ		380.9822	788.7246	15.6656	304.6006	54.4922	28.8896	18.6422
4 OBS		4.00	14.00	6.00	14.00	3.00	0.0	439.00
ASICK EXP		0.30	2.88	1.00	1.25	0.71	0.12	432.75
DEV		3.70	11.12	5.00	12.75	2.29	-0.12	-34.75
CHISQ		46.5126	42.9968	25.1410	129.5283	7.3843	0.1199	2.7900
1 OBS		5.00	55.00	31.00	32.00	23.00	1.00	11716.00
AWELL EXP		7.88	76.79	26.58	33.47	18.95	3.20	11549.13
DEV		-2.88	-21.79	4.42	-1.47	4.05	-2.20	19.88
CHISQ		1.0501	6.1827	0.7347	0.0647	0.8650	1.5121	0.0342
2 OBS		3.00	36.00	22.00	12.00	12.00	5.00	11499.00
AWELL EXP		7.73	75.37	26.09	32.85	18.60	3.14	11335.21
DEV		-4.73	-39.37	-4.09	-20.85	-6.60	1.86	73.79
CHISQ		2.8942	20.5627	0.6407	13.2355	2.3420	1.1013	0.4803
3 OBS		0.0	34.00	18.00	6.00	13.00	4.00	11549.00
AWELL EXP		7.76	75.69	26.20	33.00	18.68	3.15	11384.50
DEV		-7.76	-41.69	-8.20	-27.00	-5.68	0.85	89.50
CHISQ		7.7635	22.9664	2.5674	22.0861	1.7276	0.2270	0.7035
4 OBS		0.0	23.00	10.00	2.00	7.00	0.0	11168.00
AWELL EXP		7.51	73.20	25.34	31.91	18.06	3.05	11008.93
DEV		-7.51	-50.20	-15.34	-29.91	-11.06	-3.05	117.07
CHISQ		7.5074	34.4244	9.2843	28.0319	6.7772	3.0499	1.2449
TOTALS		32.00	312.00	108.00	136.00	77.00	13.00	47603.00

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Table D36. Analysis Method 2011. 7-day update average, 90% limits, day-to-day.

ANALYSIS PERIOD	CLINIC RECORD						CWEILL	TOTALS
	CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600		
1 OBS	3.00	42.00	1.00	24.00	1.00	1.00	380.00	452.00
ASICK EXP	0.17	2.24	0.84	0.98	0.57	0.12	447.08	
DEV	2.83	39.76	0.16	23.02	0.43	0.88	-67.08	
CHISQ	46.8291	705.4358	0.0324	541.9312	0.3250	6.2247	10.0651	
2 OBS	1.00	27.00	1.00	12.00	2.00	2.00	748.00	793.00
ASICK EXP	0.30	3.93	1.47	1.72	1.00	0.22	784.37	
DEV	0.70	23.07	-0.47	10.28	1.00	1.78	-36.37	
CHISQ	1.6348	135.3599	0.1481	61.6399	1.0014	14.6870	1.6865	
3 OBS	3.00	34.00	3.00	12.00	4.00	2.00	808.00	866.00
ASICK EXP	0.33	4.29	1.60	1.87	1.09	0.24	856.58	
DEV	2.67	29.71	1.40	10.13	2.91	1.76	-48.58	
CHISQ	21.8119	205.5473	1.2227	54.7234	7.7499	13.1500	2.7547	
4 OBS	2.00	8.00	2.00	10.00	1.00	0.0	1513.00	1536.00
ASICK EXP	0.58	7.61	2.84	3.32	1.94	0.42	1519.29	
DEV	1.42	0.39	-0.84	6.68	-0.94	-0.42	-6.29	
CHISQ	3.4678	0.0195	0.2482	13.4124	0.4525	0.4195	0.0260	
1 OBS	6.00	44.00	32.00	30.00	24.00	0.0	11412.00	11548.00
AWELL EXP	4.37	57.25	21.35	24.99	14.56	3.15	11422.33	
DEV	1.63	-13.25	10.65	5.01	9.44	-3.15	-10.33	
CHISQ	0.6110	3.0671	5.3152	1.0058	6.1284	3.1537	0.0093	
2 OBS	3.00	32.00	22.00	9.00	10.00	4.00	11127.00	11207.00
AWELL EXP	4.24	55.56	20.72	24.25	14.13	3.06	11085.05	
DEV	-1.24	-23.56	1.28	-15.25	-4.13	0.94	41.95	
CHISQ	0.3615	9.9909	0.0794	9.5893	1.2049	0.2884	0.1588	
3 OBS	0.0	29.00	18.00	5.00	11.00	4.00	11063.00	11130.00
AWELL EXP	4.21	55.18	20.58	24.08	14.03	3.04	11008.88	
DEV	-4.21	-26.18	-2.58	-19.08	-3.03	0.96	54.12	
CHISQ	4.2086	12.4202	0.3223	15.1204	0.6538	0.3035	0.2661	
4 OBS	0.0	20.00	9.00	1.00	7.00	0.0	10034.00	10071.00
AWELL EXP	3.81	49.93	18.62	21.79	12.69	2.75	9961.41	
DEV	-3.81	-29.93	-9.62	-20.79	-5.69	-2.75	72.59	
CHISQ	3.8081	17.9401	4.9682	19.8368	2.5539	2.7503	0.5290	
TOTALS	18.00	236.00	88.00	103.00	60.00	13.00	47085.00	47603.00

Table D37. Analysis Method 2012. 7-day update average, 90% limits, 6-day predictive.

ANALYSIS PERIOD	CLINIC RECORD						CWEILL	TOTALS
	CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600		
1 OBS	6.00	66.00	9.00	32.00	10.00	1.00	328.00	452.00
ASICK EXP	0.31	3.16	1.25	1.51	0.87	0.16	444.73	
DEV	5.69	62.84	7.75	30.49	9.13	0.84	-116.73	
CHISQ	103.2039	1248.8135	47.8794	615.7732	95.3479	4.3565	30.6370	
2 OBS	2.00	61.00	19.00	36.00	9.00	3.00	663.00	793.00
ASICK EXP	0.55	5.55	2.20	2.65	1.53	0.28	780.24	
DEV	1.45	55.45	16.80	33.35	7.47	2.72	-117.24	
CHISQ	3.8260	554.3218	128.3690	419.9417	36.3842	26.0632	17.6164	
3 OBS	12.00	60.00	9.00	27.00	18.00	5.00	735.00	866.00
ASICK EXP	0.60	6.06	2.40	2.89	1.67	0.31	852.06	
DEV	11.40	53.94	6.60	24.11	16.33	4.69	-117.06	
CHISQ	216.4643	480.3154	18.1322	200.9192	159.2596	71.1457	16.0834	
4 OBS	4.00	21.00	14.00	19.00	3.00	0.0	1475.00	1536.00
ASICK EXP	1.06	10.74	4.26	5.13	2.97	0.55	1511.28	
DEV	2.94	10.26	9.74	13.87	0.03	-0.55	-36.28	
CHISQ	8.0910	9.7877	22.2770	37.4949	0.0003	0.5485	0.8711	
1 OBS	6.00	44.00	32.00	30.00	24.00	0.0	11412.00	11548.00
AWELL EXP	8.01	80.78	32.02	38.57	22.32	4.12	11362.17	
DEV	-2.01	-36.78	-0.02	-8.57	1.68	-4.12	49.83	
CHISQ	0.5024	16.7480	0.0000	1.9049	0.1267	4.1240	0.2185	
2 OBS	3.00	32.00	22.00	9.00	10.00	4.00	11127.00	11207.00
AWELL EXP	7.77	78.40	31.08	37.43	21.66	4.00	11026.66	
DEV	-4.77	-46.40	-9.08	-28.43	-11.66	-0.00	100.34	
CHISQ	2.9275	27.4587	2.6509	21.5966	6.2762	0.0000	0.9131	
3 OBS	0.0	29.00	18.00	5.00	11.00	4.00	11063.00	11130.00
AWELL EXP	7.72	77.86	30.86	37.18	21.51	3.97	10950.89	
DEV	-7.72	-48.86	-12.86	-32.18	-10.51	0.03	112.11	
CHISQ	7.7157	30.6600	5.3608	27.8481	5.1356	0.0002	1.1476	
4 OBS	0.0	20.00	9.00	1.00	7.00	0.0	10034.00	10071.00
AWELL EXP	6.98	70.45	27.93	33.64	19.46	3.60	9908.94	
DEV	-6.98	-50.45	-18.93	-32.64	-12.46	-3.60	125.06	
CHISQ	6.9816	36.1280	12.8267	31.6681	7.9812	3.5966	1.5783	
TOTALS	33.00	333.00	132.00	159.00	92.00	17.00	46837.00	47603.00

Table D38. Analysis Method 2021. 7-day update average, 80% limits, day-to-day.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	2.00	23.00	0.00	8.00	1.00	0.0	94.00
ASICK	EXP	0.04	0.47	0.17	0.20	0.12	0.03	
	DEV	1.96	22.53	-0.17	7.80	0.88	-0.03	
	CHISQ	108.5721	1089.6064	0.1738	298.8689	6.5587	0.0257	
2	OBS	1.00	19.00	0.0	7.00	0.0	0.0	132.00
ASICK	EXP	0.05	0.65	0.24	0.29	0.17	0.04	
	DEV	0.95	18.35	-0.24	6.71	-0.17	-0.04	
	CHISQ	18.0848	514.2937	0.2440	157.8468	0.1664	0.0360	
3	OBS	2.00	18.00	1.00	10.00	1.00	2.00	164.00
ASICK	EXP	0.06	0.81	0.30	0.35	0.21	0.04	
	DEV	1.94	17.19	0.70	9.65	0.79	1.96	
	CHISQ	60.5647	363.3081	1.6016	262.1626	3.0444	85.3562	
4	OBS	1.00	4.00	1.00	8.00	0.0	0.0	300.00
ASICK	EXP	0.11	1.49	0.55	0.65	0.38	0.08	
	DEV	0.89	2.51	0.45	7.35	-0.38	-0.08	
	CHISQ	6.9288	4.2450	0.3577	83.2443	0.3781	0.0819	
1	OBS	7.00	63.00	33.00	46.00	24.00	1.00	11906.00
AWELL	EXP	4.50	59.03	22.01	25.76	15.01	3.25	
	DEV	2.50	3.97	10.99	20.24	8.99	-2.25	
	CHISQ	1.3861	0.2676	5.4879	15.8999	5.3897	1.5590	
2	OBS	3.00	40.00	23.00	14.00	12.00	6.00	11868.00
AWELL	EXP	4.49	58.84	21.94	25.68	14.96	3.24	
	DEV	-1.49	-18.84	1.06	-11.68	-2.96	2.76	
	CHISQ	0.4931	6.0311	0.0513	5.3118	0.5852	2.3485	
3	OBS	1.00	45.00	20.00	7.00	14.00	4.00	11832.00
AWELL	EXP	4.47	58.66	21.87	25.60	14.91	3.23	
	DEV	-3.47	-13.66	-1.87	-18.60	-0.91	0.77	
	CHISQ	2.6975	3.1806	0.1604	13.5152	0.0559	0.1829	
4	OBS	1.00	24.00	10.00	3.00	8.00	0.0	11307.00
AWELL	EXP	4.28	56.06	20.90	24.47	14.25	3.09	
	DEV	-3.28	-32.06	-10.90	-21.47	-6.25	-3.09	
	CHISQ	2.5094	18.3317	5.6865	18.8331	2.7423	3.0879	
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47603.00

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Table D39. Analysis Method 2022. 7-day update average, 80% limits, 6-day predictive.

ANALYSIS PERIOD		CLINIC RECORD					CWEILL	TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400		
1	OBS	3.00	29.00	3.00	9.00	2.00	48.00	94.00
ASICK	EXP	0.05	0.54	0.18	0.23	0.13	92.86	
	DEV	2.95	28.46	2.82	8.77	1.87	-64.86	
	CHISQ	192.2077	1514.1021	44.2647	342.0461	27.2923	21.6720	
2	OBS	2.00	30.00	0.0	11.00	1.00	88.00	132.00
ASICK	EXP	0.06	0.75	0.25	0.32	0.18	130.40	
	DEV	1.94	29.25	-0.25	10.68	0.82	-42.40	
	CHISQ	58.7818	1138.4116	0.2523	361.0886	3.7284	13.7865	
3	OBS	4.00	33.00	1.00	16.00	3.00	105.00	164.00
ASICK	EXP	0.08	0.93	0.31	0.39	0.22	162.01	
	DEV	3.92	32.07	0.69	15.61	2.78	-57.01	
	CHISQ	194.0009	1101.3376	1.5032	620.2095	34.4141	20.0626	
4	OBS	2.00	7.00	1.00	8.00	1.00	281.00	300.00
ASICK	EXP	0.14	1.71	0.57	0.72	0.41	296.36	
	DEV	1.86	5.29	0.43	7.28	0.59	-15.36	
	CHISQ	23.7409	16.3985	0.3172	73.8001	0.8508	0.7964	
1	OBS	7.00	63.00	33.00	46.00	24.00	11732.00	11906.00
AWELL	EXP	5.75	67.78	22.76	28.51	16.26	11761.68	
	DEV	1.25	-4.78	10.24	17.49	7.74	-29.68	
	CHISQ	0.2705	0.3371	4.6071	10.7255	3.6877	0.0749	
2	OBS	3.00	40.00	23.00	14.00	12.00	11770.00	11868.00
AWELL	EXP	5.73	67.56	22.69	28.42	16.21	11724.14	
	DEV	-2.73	-27.56	0.31	-14.42	-4.21	45.86	
	CHISQ	1.3037	11.2450	0.0043	7.3177	1.0913	0.1794	
3	OBS	1.00	45.00	20.00	7.00	14.00	11741.00	11832.00
AWELL	EXP	5.72	67.36	22.62	28.34	16.16	11688.58	
	DEV	-4.72	-22.36	-2.62	-21.34	-2.16	52.42	
	CHISQ	3.8917	7.4216	0.3032	16.0646	0.2877	0.2351	
4	OBS	1.00	24.00	10.00	3.00	8.00	11261.00	11307.00
AWELL	EXP	5.46	64.37	21.61	27.08	15.44	11169.94	
	DEV	-4.46	-40.37	-11.61	-24.08	-7.44	91.06	
	CHISQ	3.6462	25.3181	6.2414	21.4104	3.5845	0.7423	
TOTALS		23.00	271.00	91.00	114.00	65.00	47026.00	47603.00

Table D40. Analysis Method 2031. 7-day update average, 1 standard deviation, day-to-day.

ANALYSIS PERIOD		CLINIC RECORD					CWEILL	TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400		
1	OBS	5.00	48.00	2.00	29.00	6.00	1.00	1271.00
ASICK	EXP	0.52	6.75	2.52	2.95	1.72	0.37	1347.18
	DEV	4.48	41.25	-0.52	26.05	4.28	0.63	-76.18
	CHISQ	39.0578	251.9670	0.1065	230.3219	10.6872	1.0605	4.3077
2	OBS	1.00	33.00	6.00	16.00	7.00	2.00	2743.00
ASICK	EXP	1.06	13.92	5.19	6.08	3.54	0.77	2777.44
	DEV	-0.06	19.08	0.81	9.92	3.46	1.23	-34.44
	CHISQ	0.0036	26.1475	0.1261	16.2104	3.3839	1.9830	0.4272
3	OBS	3.00	41.00	8.00	12.00	7.00	2.00	2415.00
ASICK	EXP	0.94	12.33	4.60	5.38	3.14	0.68	2460.93
	DEV	2.06	28.67	3.40	6.62	3.86	1.32	-45.93
	CHISQ	4.5073	66.6170	2.5143	8.1325	4.7613	2.5665	0.8571
4	OBS	2.00	12.00	5.00	10.00	4.00	0.0	3191.00
ASICK	EXP	1.22	15.98	5.96	6.98	4.06	0.88	3188.92
	DEV	0.78	-3.98	-0.96	3.02	-0.06	-0.88	2.08
	CHISQ	0.5002	0.9928	0.1546	1.3110	0.0010	0.8804	0.0014
1	OBS	4.00	38.00	31.00	25.00	19.00	0.0	10521.00
AWELL	EXP	4.02	52.74	19.67	23.02	13.41	2.91	10522.24
	DEV	-0.02	-14.74	11.33	1.98	5.59	-2.91	-1.24
	CHISQ	0.0001	4.1195	6.5326	0.1707	2.3318	2.9052	0.0001
2	OBS	3.00	26.00	17.00	5.00	5.00	4.00	9132.00
AWELL	EXP	3.48	45.57	16.99	19.89	11.59	2.51	9091.97
	DEV	-0.48	-19.57	0.01	-14.89	-6.59	1.49	40.03
	CHISQ	0.0651	8.4049	0.0000	11.1460	3.7436	0.8841	0.1763
3	OBS	0.0	22.00	13.00	5.00	8.00	4.00	9456.00
AWELL	EXP	3.60	47.14	17.58	20.57	11.98	2.60	9404.54
	DEV	-3.60	-25.14	-4.58	-15.57	-3.98	1.40	51.46
	CHISQ	3.5952	13.4054	1.1917	11.7879	1.3245	0.7586	0.2816
4	OBS	0.0	16.00	6.00	1.00	4.00	0.0	8356.00
AWELL	EXP	3.17	41.56	15.50	18.14	10.57	2.29	8291.77
	DEV	-3.17	-25.56	-9.50	-17.14	-6.57	-2.29	64.23
	CHISQ	3.1698	15.7199	5.8200	16.1936	4.0804	2.2893	0.4975
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47085.00
								47603.00

Table D41. Analysis Method 2032. 7-day update average, 1 standard deviation, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1 OBS		16.00	91.00	27.00	59.00	35.00	4.00	1362.00
ASICK EXP		1.23	12.88	5.72	6.49	4.21	0.92	1330.56
DEV		14.77	78.12	21.28	52.51	30.79	3.08	-200.56
CHISQ		177.3096	474.0476	79.1179	424.4585	225.4626	10.3910	30.2299
2 OBS		4.00	97.00	48.00	61.00	25.00	13.00	2808.00
ASICK EXP		2.54	26.54	11.80	13.39	8.67	1.89	2743.17
DEV		1.46	70.46	36.20	47.61	16.33	11.11	-183.17
CHISQ		0.8444	187.0052	111.0919	169.2789	30.7487	65.4187	12.2311
3 OBS		12.00	117.00	36.00	42.00	38.00	7.00	2488.00
ASICK EXP		2.25	23.52	10.45	11.86	7.68	1.67	2430.56
DEV		9.75	93.48	25.55	30.14	30.32	5.33	-194.56
CHISQ		42.3208	371.5466	62.4352	76.5457	119.6293	16.9700	15.5740
4 OBS		4.00	43.00	22.00	29.00	13.00	0.0	3224.00
ASICK EXP		2.91	30.48	13.55	15.37	9.96	2.17	3149.57
DEV		1.09	12.52	8.45	13.63	3.04	-2.17	-36.57
CHISQ		0.4063	5.1456	5.2771	12.0768	0.9308	2.1673	0.4246
1 OBS		4.00	38.00	31.00	25.00	19.00	0.0	10521.00
AWELL EXP		9.61	100.56	44.69	50.73	32.85	7.15	10392.40
DEV		-5.61	-62.56	-13.69	-25.73	-13.85	-7.15	128.60
CHISQ		3.2744	38.9221	4.1961	13.0489	5.8397	7.1511	1.5914
2 OBS		3.00	26.00	17.00	5.00	5.00	4.00	9192.00
AWELL EXP		8.30	86.89	38.62	43.83	28.39	6.18	8979.78
DEV		-5.30	-60.89	-21.62	-38.83	-23.39	-2.18	152.22
CHISQ		3.3871	42.6733	12.1027	34.4034	19.2660	0.7685	2.5803
3 OBS		0.0	22.00	13.00	5.00	8.00	4.00	9508.00
AWELL EXP		8.59	89.88	39.95	45.34	29.36	6.39	9288.48
DEV		-8.59	-67.88	-26.95	-40.34	-21.36	-2.39	167.52
CHISQ		8.5886	51.2658	18.1776	35.8913	15.5408	0.8948	3.0211
4 OBS		0.0	16.00	6.00	1.00	4.00	0.0	8383.00
AWELL EXP		7.57	79.25	35.22	39.98	25.89	5.64	8189.46
DEV		-7.57	-63.25	-29.22	-38.98	-21.89	-5.64	166.54
CHISQ		7.5724	50.4765	24.2426	38.0002	18.5051	5.6353	3.3867
TOTALS		43.00	450.00	200.00	227.00	147.00	32.00	47603.00

Table D42. Analysis Method 2042. 7-day updated average, 2 standard deviations, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1 OBS		7.00	63.00	7.00	27.00	13.00	1.00	377.00
ASICK EXP		0.25	2.77	0.95	1.26	0.74	0.16	
DEV		6.75	60.23	6.05	25.74	12.26	0.84	
CHISQ		179.6012	1308.6492	38.5097	526.1855	201.7580	4.4718	
2 OBS		2.00	72.00	17.00	40.00	12.00	8.00	910.00
ASICK EXP		0.61	6.69	2.29	3.04	1.80	0.38	
DEV		1.39	65.31	14.71	36.96	10.20	7.62	
CHISQ		3.1506	637.4905	94.2763	449.4392	57.9330	151.7775	
3 OBS		11.00	68.00	8.00	25.00	15.00	3.00	780.00
ASICK EXP		0.52	5.73	1.97	2.61	1.54	0.33	
DEV		10.48	62.27	6.03	22.39	13.46	2.67	
CHISQ		209.2921	676.0215	18.5153	192.5011	117.6215	21.7910	
4 OBS		4.00	20.00	7.00	19.00	4.00	0.0	907.00
ASICK EXP		0.61	6.67	2.29	3.03	1.79	0.38	
DEV		3.39	13.33	4.71	15.97	2.21	-0.38	
CHISQ		18.8517	26.6504	9.7174	84.1913	2.7245	0.3811	
1 OBS		5.00	47.00	32.00	33.00	22.00	0.0	11623.00
AWELL EXP		7.81	85.46	29.30	38.82	22.95	4.88	
DEV		-2.81	-38.46	2.70	-5.82	-0.95	-4.88	
CHISQ		1.0130	17.3068	0.2488	0.8732	0.0394	4.8833	
2 OBS		3.00	30.00	21.00	9.00	10.00	4.00	11090.00
AWELL EXP		7.45	81.54	27.96	37.04	21.90	4.66	
DEV		-4.45	-51.54	-6.96	-28.04	-11.90	-0.66	
CHISQ		2.6622	32.5766	1.7309	21.2287	6.4654	0.0933	
3 OBS		0.0	30.00	18.00	5.00	11.00	4.00	11216.00
AWELL EXP		7.54	82.47	28.27	37.46	22.15	4.71	
DEV		-7.54	-52.47	-10.27	-32.46	-11.15	-0.71	
CHISQ		7.5397	33.3790	3.7332	28.1302	5.6111	0.1077	
4 OBS		0.0	20.00	10.00	1.00	7.00	0.0	10700.00
AWELL EXP		7.19	78.67	26.97	35.74	21.13	4.50	
DEV		-7.19	-58.67	-16.97	-34.74	-14.13	-4.50	
CHISQ		7.1928	43.7559	10.6805	33.7673	9.4480	4.4955	
TOTALS		32.00	350.00	120.00	159.00	94.00	20.00	47603.00

Table D43. Analysis Method 3011. 36-subclass regression comparison, 1 standard deviation, day-to-day.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1 OBS		6.00	43.00	5.00	30.00	6.00	1.00	1566.00
ASICK EXP		0.59	7.76	2.89	3.39	1.97	0.43	1548.96
DEV		5.41	35.24	2.11	26.61	4.03	0.57	-73.96
CHISQ		49.3878	159.9229	1.5307	209.0003	8.2125	0.7660	3.5314
2 OBS		1.00	26.00	1.00	12.00	3.00	3.00	1826.00
ASICK EXP		0.69	9.05	3.38	3.95	2.30	0.50	1806.13
DEV		0.31	16.95	-2.38	8.05	0.70	2.50	-26.13
CHISQ		0.1388	31.7264	1.6718	16.3977	0.2120	12.5468	0.3780
3 OBS		2.00	35.00	5.00	12.00	3.00	2.00	1505.00
ASICK EXP		0.57	7.46	2.78	3.26	1.90	0.41	1488.62
DEV		1.43	27.54	2.22	8.74	1.10	1.59	-42.62
CHISQ		3.5979	101.6418	1.7679	23.4769	0.6414	6.1433	1.2204
4 OBS		2.00	8.00	1.00	9.00	2.00	0.0	2008.00
ASICK EXP		0.76	9.96	3.71	4.34	2.53	0.55	1986.15
DEV		1.24	-1.96	-2.71	4.66	-0.53	-0.55	-0.15
CHISQ		2.0274	0.3839	1.9814	4.9879	0.1114	0.5484	0.0000
1 OBS		3.00	43.00	28.00	24.00	19.00	0.0	10434.00
AWELL EXP		3.95	51.73	19.29	22.58	13.15	2.85	10320.46
DEV		-0.95	-8.73	8.71	1.42	5.85	-2.85	-3.46
CHISQ		0.2265	1.4728	3.9344	0.0898	2.6011	2.8494	0.0012
2 OBS		3.00	33.00	22.00	9.00	9.00	3.00	10174.00
AWELL EXP		3.85	50.44	18.81	22.01	12.82	2.78	10063.28
DEV		-0.85	-17.44	3.19	-13.01	-3.82	0.22	31.72
CHISQ		0.1865	6.0296	0.5418	7.6933	1.1401	0.0177	0.1000
3 OBS		1.00	28.00	16.00	5.00	12.00	4.00	10491.00
AWELL EXP		3.97	52.01	19.39	22.70	13.22	2.87	10376.84
DEV		-2.97	-24.01	-3.39	-17.70	-1.22	1.13	48.16
CHISQ		2.2190	11.0847	0.5939	13.8010	0.1131	0.4496	0.2236
4 OBS		0.0	20.00	10.00	2.00	6.00	0.0	9599.00
AWELL EXP		3.63	47.59	17.74	20.77	12.10	2.62	9494.54
DEV		-3.63	-27.59	-7.74	-18.77	-6.10	-2.62	66.46
CHISQ		3.6296	15.9940	3.3803	16.9622	3.0743	2.6214	0.4652
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47603.00

Table D44. Analysis Method 3012. 36-subclass regression comparison, 1 standard deviation, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	13.00	85.00	31.00	64.00	28.00	1.00	1344.00
ASICK	EXP	1.22	13.03	5.63	6.81	3.62	0.66	1535.04
	DEV	11.78	71.97	25.37	57.19	24.38	0.34	-191.04
	CHISQ	114.0614	397.6338	114.4575	480.3047	164.2722	0.1778	23.7763
2	OBS	2.00	75.00	28.00	46.00	12.00	7.00	1656.00
ASICK	EXP	1.42	15.19	6.56	7.94	4.22	0.77	1789.90
	DEV	0.58	59.81	21.44	38.06	7.78	6.23	-133.90
	CHISQ	0.2376	235.4962	70.0828	182.4289	14.3469	50.6376	10.0174
3	OBS	11.00	88.00	24.00	36.00	19.00	5.00	1322.00
ASICK	EXP	1.17	12.52	5.41	6.54	3.48	0.63	1475.25
	DEV	9.83	75.48	18.59	29.46	15.52	4.37	-153.25
	CHISQ	82.6081	455.0598	63.9491	132.5750	69.2813	30.1697	15.9196
4	OBS	4.00	24.00	12.00	21.00	5.00	0.0	1942.00
ASICK	EXP	1.56	16.70	7.21	8.73	4.64	0.84	1968.31
	DEV	2.44	7.30	4.79	12.27	0.36	-0.84	-26.31
	CHISQ	3.8123	3.1866	3.1767	17.2372	0.0279	0.8436	0.3516
1	OBS	3.00	43.00	28.00	24.00	19.00	0.0	10317.00
AWELL	EXP	8.11	86.80	37.48	45.37	24.11	4.38	10227.74
	DEV	-5.11	-43.80	-9.48	-21.37	-5.11	-4.38	89.26
	CHISQ	3.2197	22.1006	2.3983	10.0670	1.0833	4.3838	0.7790
2	OBS	3.00	33.00	22.00	9.00	9.00	3.00	10095.00
AWELL	EXP	7.91	84.64	36.55	44.24	23.51	4.27	9972.88
	DEV	-4.91	-51.64	-14.55	-35.24	-14.51	-1.27	122.13
	CHISQ	3.0460	31.5024	5.7903	28.0721	8.9552	0.3800	1.4955
3	OBS	1.00	28.00	16.00	5.00	12.00	4.00	10425.00
AWELL	EXP	8.15	87.27	37.69	45.62	24.24	4.41	10283.61
	DEV	-7.15	-59.27	-21.69	-40.62	-12.24	-0.41	141.39
	CHISQ	6.2769	40.2559	12.4789	36.1677	6.1824	0.0377	1.9439
4	OBS	0.0	20.00	10.00	2.00	6.00	0.0	9561.00
AWELL	EXP	7.46	79.85	34.48	41.74	22.18	4.03	9409.25
	DEV	-7.46	-59.85	-24.48	-39.74	-16.18	-4.03	151.75
	CHISQ	7.4609	44.8614	17.3817	37.8367	11.8041	4.0329	2.4475
TOTALS		37.00	396.00	171.00	207.00	110.00	20.00	46662.00
								47603.00

Table D45. Analysis Method 3021. 36-subclass regression comparison, 2 standard deviations, day-to-day.

ANALYSIS PERIOD	CLINIC RECORD						CWEILL	TOTALS
	CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600		
1 OBS	4.00	40.00	4.00	25.00	4.00	0.00	753.00	830.00
ASICK EXP	0.31	4.11	1.53	1.80	1.05	0.23	820.97	
DEV	3.69	35.89	2.47	23.20	2.95	-0.23	-67.97	
CHISQ	43.2943	312.9487	3.9622	299.8115	8.3403	0.2267	5.6271	
2 OBS	1.00	24.00	4.00	9.00	0.0	2.00	652.00	692.00
ASICK EXP	0.26	3.43	1.28	1.50	0.87	0.19	684.47	
DEV	0.74	20.57	2.72	7.50	-0.87	1.81	-32.47	
CHISQ	2.0834	123.3260	5.7866	37.5947	0.8722	17.3553	1.5403	
3 OBS	3.00	24.00	2.00	11.00	2.00	2.00	446.00	490.00
ASICK EXP	0.19	2.43	0.91	1.06	0.62	0.13	484.67	
DEV	2.81	21.57	1.09	9.94	1.38	1.87	-38.67	
CHISQ	42.7598	191.5385	1.3217	93.1868	3.0942	26.0258	3.0850	
4 OBS	2.00	7.00	2.00	8.00	0.0	0.0	746.00	765.00
ASICK EXP	0.29	3.79	1.41	1.66	0.96	0.21	756.68	
DEV	1.71	3.21	0.59	6.34	-0.96	-0.21	-10.68	
CHISQ	10.1173	2.7125	0.2427	24.3200	0.9642	0.2089	0.1506	
1 OBS	5.00	46.00	29.00	29.00	21.00	1.00	11039.00	11170.00
AWELL EXP	4.22	55.38	20.65	24.17	14.08	3.05	11048.45	
DEV	0.78	-9.38	8.35	4.83	6.92	-2.05	-9.45	
CHISQ	0.1427	1.5879	3.3773	0.9657	3.4023	1.3783	0.0081	
2 OBS	3.00	35.00	19.00	12.00	12.00	4.00	11223.00	11308.00
AWELL EXP	4.28	56.06	20.90	24.47	14.25	3.09	11184.95	
DEV	-1.28	-21.06	-1.90	-12.47	-2.25	0.91	38.05	
CHISQ	0.3807	7.9124	0.1735	6.3528	0.3561	0.2693	0.1295	
3 OBS	0.0	39.00	19.00	6.00	13.00	4.00	11425.00	11506.00
AWELL EXP	4.35	57.04	21.27	24.90	14.50	3.14	11380.79	
DEV	-4.35	-18.04	-2.27	-18.90	-1.50	0.86	44.21	
CHISQ	4.3507	5.7071	0.2423	14.3419	0.1557	0.2342	0.1717	
4 OBS	0.0	21.00	9.00	3.00	8.00	0.0	10801.00	10842.00
AWELL EXP	4.10	53.75	20.04	23.46	13.67	2.96	10724.02	
DEV	-4.10	-32.75	-11.04	-20.46	-5.67	-2.96	76.98	
CHISQ	4.0997	19.9555	6.0841	17.8428	2.3488	2.9609	0.5526	
TOTALS	18.00	236.00	88.00	103.00	60.00	13.00	47085.00	47603.00

Table D46. Analysis Method 3022. 36-subclass regression comparison, 2 standard deviations, 6-day predictive.

ANALYSIS PERIOD		CLINIC RECORD					CWELL	TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400		
1	OBS	7.00	70.00	19.00	44.00	15.00	675.00	830.00
ASICK	EXP	0.52	5.70	2.23	2.60	1.64	817.04	
	DEV	6.48	64.30	16.77	41.40	13.36	-142.04	
	CHISQ	80.1996	725.1189	125.9852	659.8020	108.9201	24.6948	
2	OBS	2.00	47.00	25.00	21.00	8.00	585.00	692.00
ASICK	EXP	0.44	4.75	1.86	2.17	1.37	681.20	
	DEV	1.56	42.25	23.14	18.83	6.63	-96.20	
	CHISQ	5.6082	375.4570	287.7512	163.7673	32.2025	13.5852	
3	OBS	10.00	50.00	4.00	21.00	11.00	392.00	490.00
ASICK	EXP	0.31	3.37	1.32	1.53	0.97	482.35	
	DEV	9.69	46.63	2.68	19.47	10.03	-90.35	
	CHISQ	304.1387	646.0950	5.4612	247.0683	104.0210	16.9242	
4	OBS	3.00	19.00	4.00	13.00	6.00	720.00	765.00
ASICK	EXP	0.48	5.26	2.06	2.39	1.51	753.06	
	DEV	2.52	13.74	1.94	10.61	4.49	-33.06	
	CHISQ	13.1500	35.9512	1.8353	46.9731	13.3419	1.4513	
1	OBS	5.00	46.00	29.00	29.00	21.00	11039.00	11170.00
AWELL	EXP	7.04	76.73	30.04	34.96	22.06	10995.65	
	DEV	-2.04	-30.73	-1.04	-5.96	-1.06	43.35	
	CHISQ	0.5909	12.3074	0.0357	1.0169	0.0507	0.1709	
2	OBS	3.00	35.00	19.00	12.00	12.00	11223.00	11308.00
AWELL	EXP	7.13	77.68	30.41	35.39	22.33	11131.50	
	DEV	-4.13	-42.68	-11.41	-23.39	-10.33	91.50	
	CHISQ	2.3893	23.4484	4.2787	15.4631	4.7784	0.7521	
3	OBS	0.0	39.00	19.00	6.00	13.00	11425.00	11506.00
AWELL	EXP	7.25	79.04	30.94	36.01	22.72	11326.41	
	DEV	-7.25	-40.04	-11.94	-30.01	-9.72	98.59	
	CHISQ	7.2512	20.2822	4.6068	25.0140	4.1587	0.8582	
4	OBS	0.0	21.00	9.00	3.00	8.00	10801.00	10842.00
AWELL	EXP	6.83	74.48	29.15	33.94	21.41	10672.77	
	DEV	-6.83	-53.48	-20.15	-30.94	-13.41	128.23	
	CHISQ	6.8328	38.3984	13.9315	28.2012	8.3987	1.5406	
TOTALS		30.00	327.00	128.00	149.00	94.00	46860.00	47603.00

Table D47. Analysis Method 3411. 3-subclass regression comparison, 1 standard deviation, day-to-day.

ANALYSIS PERIOD		CLINIC RECORD					CWELL	TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400		
1	OBS	6.00	43.00	4.00	31.00	6.00	1464.00	1555.00
ASICK	EXP	0.59	7.71	2.87	3.36	1.96	1538.08	
	DEV	5.41	35.29	1.13	27.64	4.04	-74.08	
	CHISQ	49.8137	161.5531	0.4406	226.9854	8.3277	3.5679	
2	OBS	2.00	26.00	2.00	12.00	2.00	1791.00	1837.00
ASICK	EXP	0.69	9.11	3.40	3.97	2.32	1817.01	
	DEV	1.31	16.89	-1.40	8.03	-0.32	-26.01	
	CHISQ	2.4532	31.3338	0.5738	16.2033	0.0430	0.3723	
3	OBS	2.00	32.00	3.00	12.00	4.00	1504.00	1559.00
ASICK	EXP	0.59	7.73	2.88	3.37	1.97	1542.04	
	DEV	1.41	24.27	0.12	8.63	2.03	-38.04	
	CHISQ	3.3749	76.2168	0.0048	22.0620	2.1075	0.9382	
4	OBS	2.00	7.00	1.00	9.00	3.00	1942.00	1964.00
ASICK	EXP	0.74	9.74	3.63	4.25	2.48	1942.63	
	DEV	1.26	-2.74	-2.63	4.75	0.52	-0.63	
	CHISQ	2.1288	0.7693	1.9061	5.3103	0.1111	0.0002	
1	OBS	3.00	43.00	29.00	23.00	19.00	10328.00	10445.00
AWELL	EXP	3.95	51.78	19.31	22.60	13.17	10331.34	
	DEV	-0.95	-8.78	9.69	0.40	5.83	-3.34	
	CHISQ	0.2283	1.4897	4.8640	0.0071	2.5860	0.0011	
2	OBS	2.00	33.00	21.00	9.00	10.00	10084.00	10163.00
AWELL	EXP	3.84	50.38	18.79	21.99	12.81	10052.40	
	DEV	-1.84	-17.38	2.21	-12.99	-2.81	31.60	
	CHISQ	0.8838	5.9985	0.2605	7.6735	0.6163	0.0993	
3	OBS	1.00	31.00	18.00	5.00	11.00	10367.00	10437.00
AWELL	EXP	3.95	51.74	19.29	22.58	13.16	10323.43	
	DEV	-2.95	-20.74	-1.29	-17.58	-2.16	43.57	
	CHISQ	2.1999	8.3157	0.0868	13.6899	0.3530	0.1839	
4	OBS	0.0	21.00	10.00	2.00	5.00	9605.00	9643.00
AWELL	EXP	3.65	47.81	17.83	20.86	12.15	9538.07	
	DEV	-3.65	-26.81	-7.83	-18.86	-7.15	66.93	
	CHISQ	3.6463	15.0314	3.4360	17.0565	4.2112	0.4697	
TOTALS		18.00	236.00	88.00	103.00	60.00	47085.00	47603.00

Table D48. Analysis Method 3412. 3-subclass regression comparison, 1 standard deviation, 6-day predictive.

ANALYSIS PERIOD		CLINIC RECORD					CWEILL	TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400		
1	OBS	13.00	89.00	28.00	66.00	30.00	4.00	1325.00
ASICK	EXP	1.24	13.16	5.46	6.79	3.79	0.88	1523.67
	DEV	11.76	75.84	22.54	59.21	26.21	3.12	-198.67
	CHISQ	111.3880	436.8625	93.1706	515.8982	181.3028	11.0229	25.9051
2	OBS	4.00	69.00	29.00	45.00	15.00	10.00	1665.00
ASICK	EXP	1.47	15.55	6.44	8.03	4.48	1.04	1799.99
	DEV	2.53	58.45	22.56	36.97	10.52	8.96	-134.99
	CHISQ	4.3773	183.6905	78.9427	170.3089	24.7396	77.0177	10.1238
3	OBS	11.00	88.00	19.00	36.00	20.00	5.00	1380.00
ASICK	EXP	1.24	13.20	5.47	6.81	3.80	0.88	1527.59
	DEV	9.76	74.80	13.53	29.19	16.20	4.12	-147.59
	CHISQ	76.4722	423.9417	33.4746	125.0642	69.0897	19.1567	14.2600
4	OBS	4.00	29.00	13.00	22.00	6.00	0.0	1890.00
ASICK	EXP	1.57	16.63	6.89	8.58	4.79	1.11	1924.43
	DEV	2.43	12.37	6.11	13.42	1.21	-1.11	-34.43
	CHISQ	3.7732	9.2075	5.4181	20.9811	0.3080	1.1140	0.6161
1	OBS	3.00	43.00	29.00	23.00	19.00	0.0	10328.00
AWELL	EXP	8.34	88.43	36.64	45.64	25.45	5.92	10234.57
	DEV	-5.34	-45.43	-7.64	-22.64	-6.45	-5.92	93.43
	CHISQ	3.4173	23.3360	1.5942	11.2301	1.6358	5.9243	0.8529
2	OBS	2.00	33.00	21.00	9.00	10.00	4.00	10084.00
AWELL	EXP	8.11	86.04	35.65	44.41	24.77	5.76	9958.25
	DEV	-6.11	-53.04	-14.65	-35.41	-14.77	-1.76	125.75
	CHISQ	4.6059	32.6956	6.0227	28.2310	8.8033	0.5400	1.5878
3	OBS	1.00	31.00	18.00	5.00	11.00	4.00	10367.00
AWELL	EXP	8.33	88.36	36.61	45.60	25.43	5.92	10226.74
	DEV	-7.33	-57.36	-18.61	-40.60	-14.43	-1.92	140.26
	CHISQ	6.4516	37.2343	9.4637	36.1524	8.1907	0.6226	1.9237
4	OBS	0.0	21.00	10.00	2.00	5.00	0.0	9605.00
AWELL	EXP	7.70	81.64	33.83	42.13	23.50	5.47	9448.73
	DEV	-7.70	-60.64	-23.83	-40.13	-18.50	-5.47	156.27
	CHISQ	7.6977	45.0382	16.7854	38.2297	14.5622	5.4694	2.5846
TOTALS		38.00	403.00	167.00	208.00	116.00	27.00	46644.00
								47603.00

Table D49. Analysis Method 3421. 3-subclass regression, 2 standard deviations, day-to-day.

ANALYSIS PERIOD		CLINIC RECORD					CWEILL	TOTALS
		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400		
1	OBS	4.00	36.00	4.00	22.00	5.00	1.00	717.00
ASICK	EXP	0.30	3.91	1.46	1.71	0.99	0.22	780.41
	DEV	3.70	32.09	2.54	20.29	4.01	0.78	-63.41
	CHISQ	45.9280	263.2334	4.4283	241.2153	16.1333	2.8565	5.1529
2	OBS	1.00	26.00	3.00	9.00	0.0	2.00	610.00
ASICK	EXP	0.25	3.23	1.20	1.41	0.82	0.18	643.92
	DEV	0.75	22.77	1.80	7.59	-0.82	1.82	-33.92
	CHISQ	2.3085	160.6811	2.6819	40.9130	0.8205	18.6771	1.7864
3	OBS	3.00	28.00	3.00	12.00	3.00	2.00	407.00
ASICK	EXP	0.17	2.27	0.85	0.99	0.58	0.13	453.02
	DEV	2.83	25.73	2.15	11.01	2.42	1.87	-46.02
	CHISQ	46.1415	291.5518	5.4766	122.3005	10.1678	28.1056	4.6742
4	OBS	2.00	6.00	2.00	8.00	1.00	0.0	750.00
ASICK	EXP	0.29	3.81	1.42	1.66	0.97	0.21	760.63
	DEV	1.71	2.19	0.58	6.34	0.03	-0.21	-10.63
	CHISQ	10.0469	1.2552	0.2353	24.1276	0.0010	0.2100	0.1486
1	OBS	5.00	50.00	29.00	32.00	20.00	0.0	11075.00
AWELL	EXP	4.24	55.58	20.72	24.26	14.13	3.06	11089.00
	DEV	0.76	-5.58	8.28	7.74	5.87	-3.06	-14.00
	CHISQ	0.1365	0.5603	3.3041	2.4712	2.4379	3.0616	0.0177
2	OBS	3.00	33.00	20.00	12.00	12.00	4.00	11265.00
AWELL	EXP	4.29	56.26	20.98	24.56	14.30	3.10	11225.50
	DEV	-1.29	-23.26	-0.98	-12.56	-2.30	0.90	39.50
	CHISQ	0.3886	9.6196	0.0458	6.4203	0.3713	0.2617	0.1390
3	OBS	0.0	35.00	18.00	5.00	12.00	4.00	11464.00
AWELL	EXP	4.36	57.20	21.33	24.97	14.54	3.15	11412.44
	DEV	-4.36	-22.20	-3.33	-19.97	-2.54	0.85	51.56
	CHISQ	4.3628	8.6171	0.5197	15.9665	0.4446	0.2288	0.2329
4	OBS	0.0	22.00	9.00	3.00	7.00	0.0	10797.00
AWELL	EXP	4.10	53.73	20.04	23.45	13.66	2.96	10720.06
	DEV	-4.10	-31.73	-11.04	-20.45	-6.66	-2.96	76.04
	CHISQ	4.0981	18.7390	6.0782	17.8343	3.2475	2.9598	0.5522
TOTALS		18.00	236.00	88.00	103.00	60.00	13.00	47085.00
								47603.00

Table D50. Analysis Method 3422. 3-subclass regression, 2 standard deviations, 6-day predictive.

ANALYSIS		CLINIC RECORD						TOTALS
PERIOD		CSICK010	CSICK100	CSICK200	CSICK300	CSICK400	CSICK600	
1	OBS	7.00	69.00	17.00	42.00	18.00	1.00	635.00
ASICK	EXP	0.51	5.60	2.01	2.47	1.57	0.23	776.60
	DEV	6.49	63.40	14.99	39.53	16.43	0.77	-141.60
	CHISQ	81.8794	717.4451	112.1075	632.7512	171.3430	2.5416	25.8191
2	OBS	2.00	56.00	16.00	20.00	7.00	3.00	547.00
ASICK	EXP	0.42	4.62	1.65	2.04	1.30	0.19	640.77
	DEV	1.58	51.38	14.35	17.96	5.70	2.81	-93.77
	CHISQ	5.8591	571.0642	124.3611	158.3405	25.0152	41.1990	13.7223
3	OBS	11.00	55.00	6.00	22.00	14.00	2.00	348.00
ASICK	EXP	0.30	3.25	1.16	1.43	0.91	0.13	450.80
	DEV	10.70	51.75	4.84	20.57	13.09	1.87	-102.80
	CHISQ	383.9863	823.4543	20.0875	295.0530	187.3518	25.8309	23.4436
4	OBS	3.00	18.00	6.00	13.00	5.00	0.0	724.00
ASICK	EXP	0.50	5.46	1.95	2.41	1.53	0.23	756.92
	DEV	2.50	12.54	4.05	10.59	3.47	-0.23	-32.92
	CHISQ	12.4725	28.7987	8.3720	46.6185	7.8248	0.2262	1.4314
1	OBS	5.00	50.00	29.00	32.00	20.00	0.0	11075.00
AWELL	EXP	7.30	79.60	28.50	35.09	22.37	3.30	11034.83
	DEV	-2.30	-29.60	0.50	-3.09	-2.37	-3.30	40.17
	CHISQ	0.7251	11.0085	0.0089	0.2723	0.2518	3.2971	0.1462
2	OBS	3.00	33.00	20.00	12.00	12.00	4.00	11265.00
AWELL	EXP	7.39	80.58	28.85	35.52	22.65	3.34	11170.67
	DEV	-4.39	-47.58	-8.85	-23.52	-10.65	0.66	94.33
	CHISQ	2.6084	28.0965	2.7135	15.5767	5.0068	0.1314	0.7966
3	OBS	0.0	35.00	18.00	5.00	12.00	4.00	11464.00
AWELL	EXP	7.51	81.92	29.33	36.11	23.03	3.39	11356.70
	DEV	-7.51	-46.92	-11.33	-31.11	-11.03	0.61	107.30
	CHISQ	7.5138	26.8772	4.3754	26.8068	5.2798	0.1085	1.0139
4	OBS	0.0	22.00	9.00	3.00	7.00	0.0	10797.00
AWELL	EXP	7.06	76.95	27.55	33.92	21.63	3.19	10667.70
	DEV	-7.06	-54.95	-18.55	-30.92	-14.63	-3.19	129.30
	CHISQ	7.0579	39.2435	12.4889	28.1888	9.8946	3.1874	1.5673
TOTALS		31.00	338.00	121.00	149.00	95.00	14.00	46855.00
								47603.00

VITA

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Doctor of Philosophy

1. Born November 5, 1940, Spokane, Washington, son of Maurice J. and Dortha F. Hyde.

2. Education:

Graduated as Valedictorian, Almira High School, Almira, Washington, Class of 1959.

B.S. Agricultural Engineering, with Honors, Washington State University, 1964.

M.S. Agricultural Engineering, Washington State University, 1969.

3. Professional Experience:

1964-66 Machine design engineer, Hyster Company, Portland, Oregon

1966-69 Agricultural Engineer, USDA, ARS, Project Leader and Collaborator, Agricultural Engineering Department, Washington State University, Pullman, Washington

1969 -- Agricultural Engineer, USDA, ARS, North Central Region, and Collaborator, Agricultural Engineering Department, University of Illinois, Urbana, Illinois

4. Present work: Research in automation of livestock production systems, primarily automatic feeding and monitoring systems for dairy cows. Concurrently working to fulfill requirements for the Ph.D. degree in engineering, which will be completed August, 1975.

5. States in which registered: Washington, Engineer-in-Training.

6. Scientific and professional societies of which a member:

American Society of Agricultural Engineers (ASAE) - Committees

EPP-42, Electrical Controls for Farmstead Equipment - Past Chairman

EPP-34, Materials Handling Committee - Secretary

PM-58, Vehicular Automation Committee - Secretary elect
 EPP-41, Milk Handling Equipment Committee - Secretary
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7. Publications:

- Hyde, G. M. 1969. Analysis and synthesis of an automatic feed-proportioning system. M.S. Thesis, Agricultural Engineering, Washington State University.
- Hyde, G. M., H. B. Puckett, and K. E. Harshbarger. 1970. Automatic proportioning of roughage and concentrates for dairy cattle. Prepared for the V International Zootechny Symposium, Milan, Italy, April.
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