Mathematical Models of Radionuclides in Milk

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IN a recent report Campbell and associates (*1*) summarized specific radionuclide activities determined in monthly milk samples collected in milksheds serving New York City, Cincinnati, St. Louis, Salt Lake City, and Sacramento. In each milkshed all samples collected have come from the same group of farms within a small geographic area. Sampling at these locations began in May 1957 and is continuing, and new sampling stations in the milksheds of Atlanta, Austin, Tex., Chicago, Fargo, and Spokane were added in July and August 1958. At each station, concentrations of strontium 89, strontium 90, cesium 137, barium 140, and iodine 131 have been measured as micromicrocuries per liter.

This report discusses several mathematical models constructed to describe the month-by-month fluctuations observed in specific nuclide concentrations at each sampling site. So far, these models have been applied only to the short-lived nuclides, strontium 89, barium 140, and iodine 131. Only data from the original five milksheds have been included since the other stations do not provide a sufficiently long record of the short-lived nuclides to test these models. Since methods of chemical determination were not standardized until August 1957, measurements obtained during the ensuing 17 months, through December 1958, were used to estimate parameters; results from January through September 1959 provided a test of the model's predictive ability.

Concentrations of short-lived nuclides observed in milk during these months are plotted in the charts, and the points are joined by solid lines. Data for August 1957 through April 1958 were taken from the report by Campbell and associates (*1*); those for May 1958 through September 1959 are now in press (*2*). (Data for August 1957 through February 1959 were also published in congressional hearings (*3a*).) Since the published measurements of strontium 89 were not corrected for decay between times of collection and counting, they appear lower than the corrected values used in this analysis.

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Factors Included in the Model

It is not difficult to list a number of factors which have probably influenced the observed concentrations of short-lived radionuclides in milk. Among these are (*a*) the pattern and characteristics of the nuclear weapons tests held by the United States, United Kingdom, and U.S.S.R., (*b*) variable trajectories of radioactive material produced by individual weapons tests, (*c*) variable detention times of such materials in the upper air, (*d*) radioactive decay, (*e*) local monthly precipitation, and (*f*) feeding practices of cattle in the milksheds where samples have been collected. More subtle influences may be the distribution of radionuclides according to the height of pasture vegetation,

affecting the month-by-month availability of these elements, and perhaps seasonally variable discrimination by cattle between calcium and radiostrontium.

All of these plus many other influences of an ecologic, meteorologic, or metabolic nature have doubtless played roles in determining the reported concentrations, assuming, of course, that composite samples from collecting stations adequately represent the milk produced in the area and that the chemical methods of analysis have been reliable. However, if we propose to construct a practical model for describing nuclide concentrations in milk, it becomes necessary to include only those factors about which reasonably full knowledge exists or can be obtained for each milkshed.

Of the six factors listed above, only (*a*), (*d*), (*e*), and (*f*) even partly meet this condition. The following sources provided information on them:

Weapons tests. A recent authoritative list (*4*) gives date, location, and approximate energy yield of nuclear weapons tests from 1945 through 1958. For this study, tests have been classed into two groups, those occurring inside continental United States and those occurring outside. Wherever possible, tests in each category were assigned a score value in an attempt to classify them according to yield. The scoring scheme, given in the following tabulation, is obviously crude, particularly with respect to outside tests.

Inside continental United States

Yield	*Score*
<5 kilotons	0
5 kilotons–½ nominal[1] or well below nominal	1
About half nominal	2
Less than nominal or above half nominal	3
Nominal	4
Above nominal	5
Several times nominal	9

Outside continental United States

No yield given	1
Moderate, moderate to high, or not in megaton range	1
Relatively high, large, megaton range, hydrogen bomb, or substantial size	2

[1] Nominal=20 kilotons

A lapse of 2 weeks for inside tests and 1 month for outside tests was assumed to have occurred between the date of a weapons test and the time when its fallout might have affected the nuclide concentration in milk of cows on pasture. A shorter time lapse might have been more accurate for some tests, but calculations with both shorter and longer lapses indicated that 2 weeks and 1 month were the best uniform choices.

We have further assumed that essentially all the fallout of short-lived nuclides occurs immediately following these lapses, moderated in amount by available precipitation. Martell and Drevinsky (*5*) maintain that short-lived fallout in the United States from Pacific and Soviet tests is of stratospheric origin and may reflect up to several months of upper air storage (see fig. 1 of their paper). Data on strontium 89 during the spring of 1959 in milk samples from St. Louis, Cincinnati, and Sacramento milksheds appear to confirm this hypothesis. In these or similar circumstances, the assumption that all fallout will occur shortly after the test may represent an invalid simplification. However, it will be seen to work fairly well when applied to observed concentrations derived from many series of weapons tests. This point will be discussed later.

Radioactive decay. The half-lives of strontium 89, barium 140, and iodine 131 are known to be (approximately) 54 days, 12.8 days, and 8 days, respectively. With respect to these nuclides, the contribution from any nuclear weapons test was assumed negligible after 12 months.

Local precipitation. Data on daily precipitation (in inches of water equivalent) for each milkshed county were obtained from local climatologic summaries issued monthly for each State by the U.S. Weather Bureau. The index used was average monthly precipitation per county over the entire milkshed area.

Feeding practices. The estimated proportion of cows on pasture in each milkshed, by month, was the only index used. The estimates, given in table 1, were based on individual farm surveys conducted by local health officers or dairy plant officials (*1*). Animals in the barn were assumed to be feeding on locally harvested grain plus supplement, an assumption largely verified by information supplied during the farm surveys. A uniform harvest date of Au-

gust 15 was applied as needed in developing the models. Any such date would be of no consequence in southern States where cows are on pasture all year round.

Construction of a Model

A model incorporating these factors may perhaps best be developed through an example. Suppose that we wish to account for the observed concentration of strontium 89 in milk from the St. Louis area during October 1958. Recall two assumptions: one, that 2 weeks and 1 month elapse before radioactive material from tests inside and outside the United States affect the milk and, two, that local feed is harvested about August 15. It follows that all cows in the milkshed have been exposed to accumulating and decaying fallout from month-after-month testing programs prior to July 15 (outside tests) or August 1 (inside tests), 1958.

During October in the milkshed serving St. Louis, an estimated 45 percent of the cows are on pasture. The remaining 55 percent are assumed shielded from any immediate effects of tests between August 1 and October 1 (date of milk sample collection was October 15), although each cow in this 55 percent group was probably on pasture for some time during this 2-month period. We are assuming, therefore, that each month's concentration of radionuclides in the milk reflects only those ingested shortly before collection of the sample. This assumption accords with statements by C. L. Comar (*3b*), who reported results of an experiment on dairy cows indicating that 96.5 percent of strontium 90 eaten by a cow is eliminated within a day in the feces or urine and about 1 percent in the milk, while almost all the remainder is deposited in the bone.

Let w_{1j} denote the yield score assigned to the latest inside test prior to October 1, 1958, where the subscript j refers to the test date. Multiply w_{1j} by its decay factor $e^{-\lambda t_{jk}}$ where t_{jk} denotes the elapsed time between the test date and the date of sample collection and λ is a radioactive decay constant equal to 0.691 divided by the half-life in months (thus, $\lambda=0.39$ for strontium 89). Summing such products for tests back to August 1 and multiplying this sum by 0.45 computes that part of the contribution from inside tests to strontium 89 in milk through the pastured group of cows in the St. Louis area during October 1958. The remaining contribution is calculated by summing similar products (multiplied by unity rather than 0.45) for tests between October 1957 and August 1, 1958. An identical operation with respect to outside tests scored as w_{2j}, starting with the latest test prior to September 15, 1958, completes the total contribution of strontium 89 activity.

So far the model has taken no account of monthly fluctuations in precipitation. This factor may be included in either of two ways: One, multiply each yield score, w_{1j} or w_{2j}, by the monthly local precipitation covering the fallout date for that test, for example, August precipitation for an outside test on July 15 or July precipitation for an inside test on July 10; or, two, multiply each summed product, say

$$\sum_j w_{ij}e^{-\lambda t_{jk}},$$

by the index during the kth month, that is, the month of sample collection. The first of these procedures has been adopted. It is the more log-

Table 1. Estimated proportion of cows on pasture, by month and State

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wisconsin	0. 00	0. 00	0. 00	0. 32	0. 92	0. 95	0. 95	0. 95	0. 95	0. 50	0. 00	0. 00
Texas	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00
North Dakota and Minnesota	. 00	. 00	. 00	. 04	. 84	. 94	. 96	. 96	. 86	. 69	. 00	. 00
California	. 08	. 10	. 47	. 81	. 84	. 84	. 84	. 84	. 83	. 72	. 32	. 12
Ohio	. 20	. 20	. 22	. 36	1. 00	1. 00	1. 00	1. 00	1. 00	. 98	. 78	. 37
Missouri	. 01	. 02	. 13	. 94	. 97	. 97	. 97	. 95	. 93	. 45	. 09	. 03
Georgia	. 98	. 98	. 98	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	1. 00	. 98	. 98
New York	. 00	. 00	. 00	. 00	. 62	1. 00	1. 00	1. 00	1. 00	. 87	. 01	. 01
Utah	. 00	. 00	. 00	. 00	. 61	. 71	. 75	. 75	. 78	. 45	. 02	. 00

ical in view of our assumption that essentially all the short-lived fallout from each test occurs immediately following a defined lapse period.

Finally, to convert the weighted yield scores to micromicrocuries of activity per liter of milk, we multiply the separate contributions from inside and outside tests by scale factors a_1 and a_2, respectively. At this point, then, the model for a specific nuclide may be expressed as follows:

$$Y_{ik}=a_{1i}\left(\sum_{j=k-12}^{\text{Aug. 1}} r_{ij}w_{1j}e^{-\lambda t_{jk}}+p_{ik}\sum_{j>\text{Aug. 1}}^{k-\frac{1}{2}} r_{ij}w_{1j}e^{-\lambda t_{jk}}\right)+a_{2i}\left(\sum_{j=k-12}^{\text{July 15}} r_{ij}w_{2j}e^{-\lambda t_{jk}}+p_{ik}\sum_{j>\text{July 15}}^{k-1} r_{ij}w_{2j}e^{-\lambda t_{jk}}\right) \quad [1]$$

where

Y_{ik} denotes the concentration of the given radionuclide during the kth month in the ith milkshed,

p_{ik} represents the estimated proportion of cows on pasture during the kth month in the ith milkshed, and

r_{ij} denotes average precipitation in inches of water over the ith milkshed during the month of fallout from the jth test.

The other symbols have already been defined.

The coefficients a_{1i} and a_{2i} are estimated by ordinary least squares, the quantities in parentheses serving as the two independent variables. Equation 1 is written for an individual milkshed, allowing separate coefficients to be estimated for each shed.

This model requires that each weapons test be handled individually although many small tests were assigned a score of zero. Therefore, many calculations of elapsed times, decay functions, and subsequent products and sums were necessary for each of the 15 nuclide-milkshed combinations. To expedite computation, the model was programed and run on an electronic computer.

Simpler Models

If local precipitation, though not constant, were always sufficient to return to earth an amount of short-lived radioactive material roughly proportional to the yield of the test from which it originated, the coefficients a_{1i} and a_{2i} would include this proportional factor, and there would be no need to introduce precipitation explicitly. This slightly simpler version of model 1 will be called 1a.

Comparison of the charts with table 1 shows that the seasonal pattern of observed concentrations tends to follow similar changes in the proportion of cows on pasture. This finding has been further supported by data from Atlanta and Austin (*2*), where cows were almost always on pasture. In these cities, short-lived nuclide concentrations did not decline during the winter months. The general correspondence between short-lived nuclides in milk and the proportion of cows on pasture indicates that by far the greatest amount of activity is derived from feed or air rather than surface waters. This agrees with findings by Comar and associates (*6*).

Relying on the feeding practices index to explain the general seasonal pattern, one may call upon local precipitation during the month of sample collection to account for monthly deviations from the seasonal level. We might then be able to describe observed fluctuations in nuclide concentrations with a much simpler model, ignoring entirely the schedule of weapons tests.

These two factors, the proportion of cows on pasture and monthly precipitation, may be combined in a variety of forms. Two basic models are:

$$Y_{ik}=ap_{ik}r_{ik} \quad [2]$$

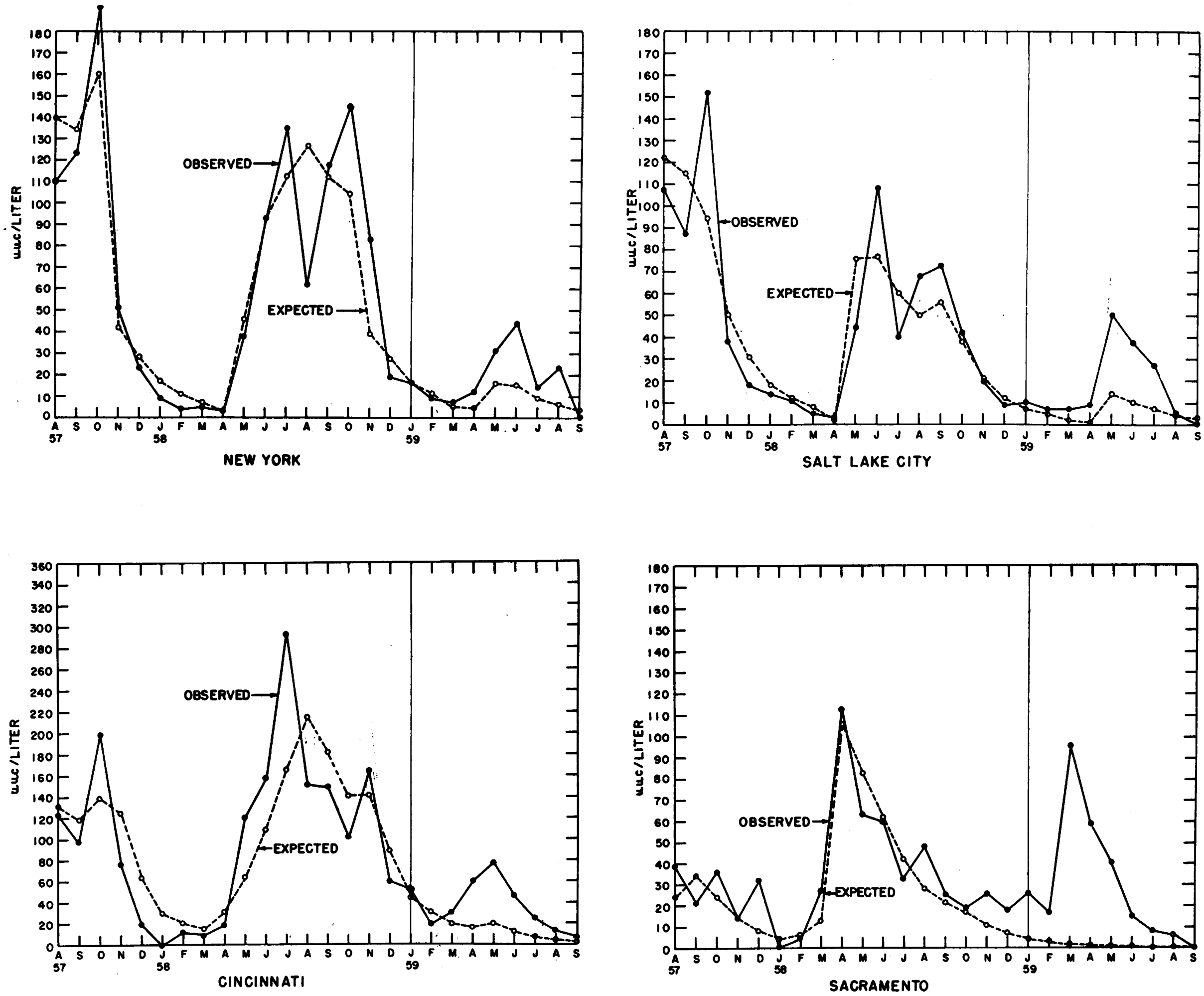
and

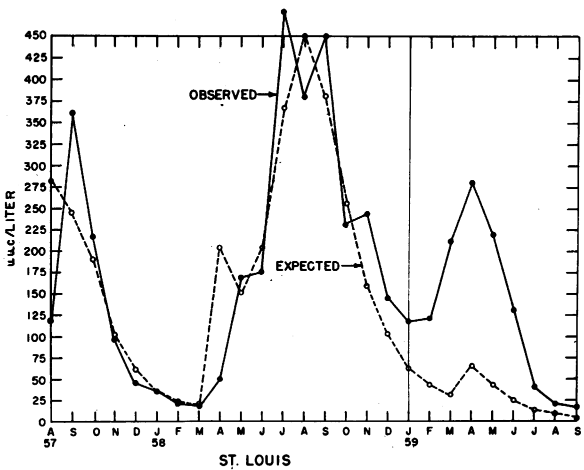
$$Y_{ik}=a_1p_{ik}+a_2r_{ik} \quad [3]$$

where the a's, as before, are scale coefficients to be estimated by least squares.

Model 2 asserts that the concentration of any nuclide in milk collected during a given month will be zero if precipitation is zero during that month or if all cows are kept in the barn. Model 3 allows these factors to operate independently. Another formula, obtained by adding equations 2 and 3, will be referred to as model 4. These models would not apply to strontium 90 and cesium 137, which have not shown the marked fluctuations characteristic

Figure 1. STRONTIUM 89: Observed and expected concentrations in samples of milk from specified milksheds, August 1957–September 1959



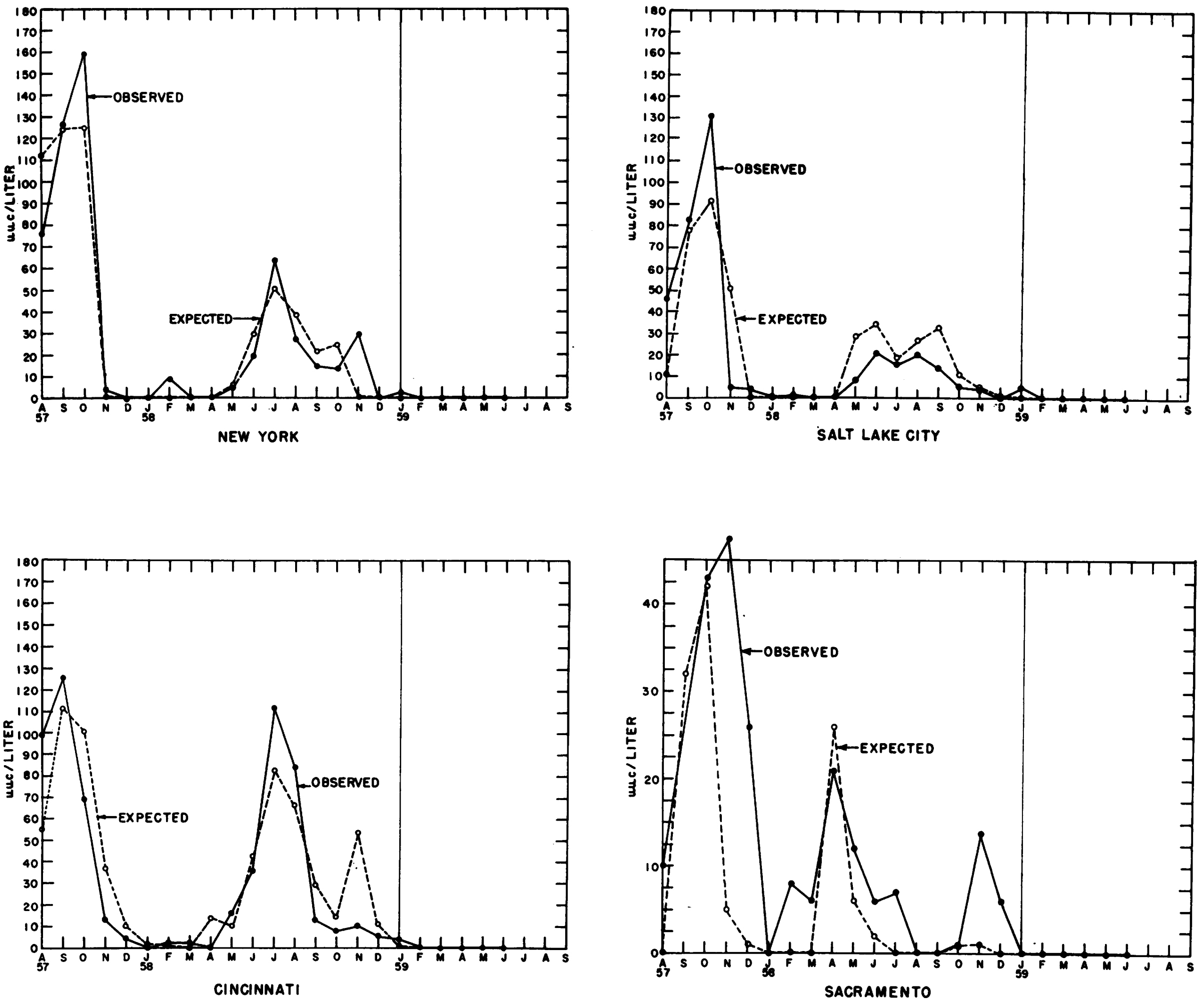


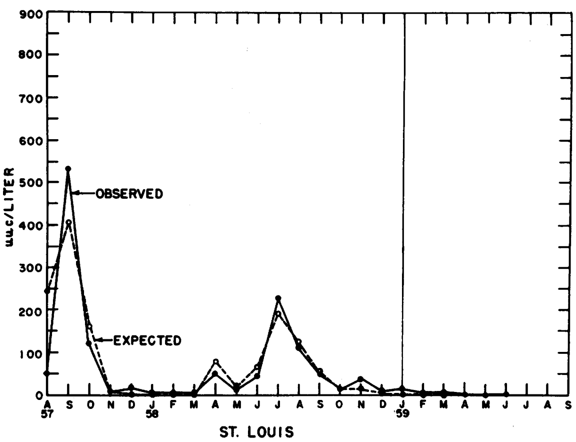
of the short-lived material even during months when both p_{ik} and r_{ik} were zero in a given milkshed. Addition of a linear time trend $(a+bt)$ might overcome this difficulty and also describe the gradual increase in strontium 90 and cesium 137 levels observed during this period of time.

Results of Model Fitting

Results of fitting model 1 and its simpler version 1a, in which precipitation is not explicitly included, show that the former was not uniformly superior. Model 1 showed substantially better agreement with the strontium 89 data in St. Louis and Sacramento, and slightly

Figure 2. BARIUM 140: Observed and expected concentrations in samples of milk from specified milksheds, August 1957–September 1959



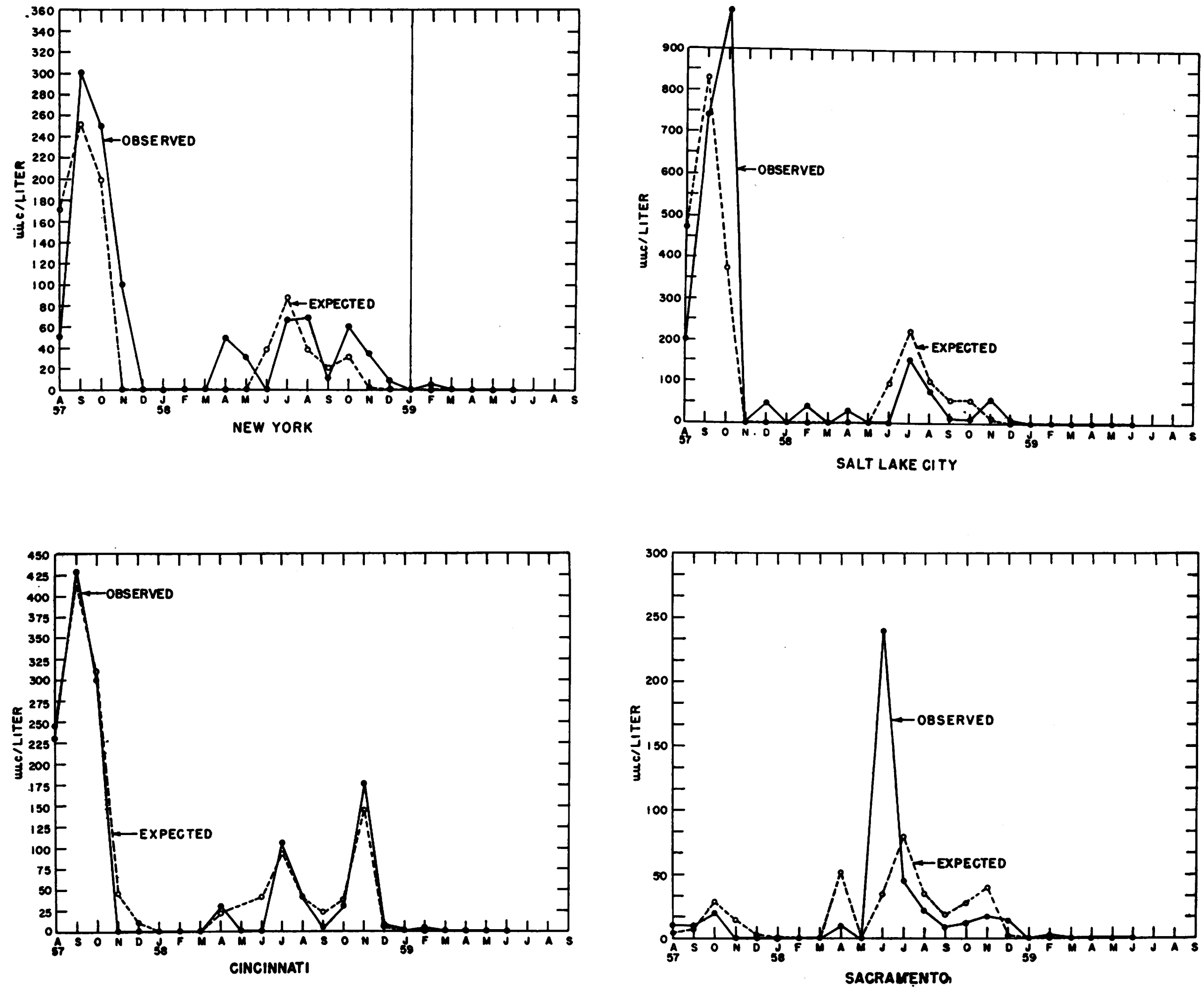


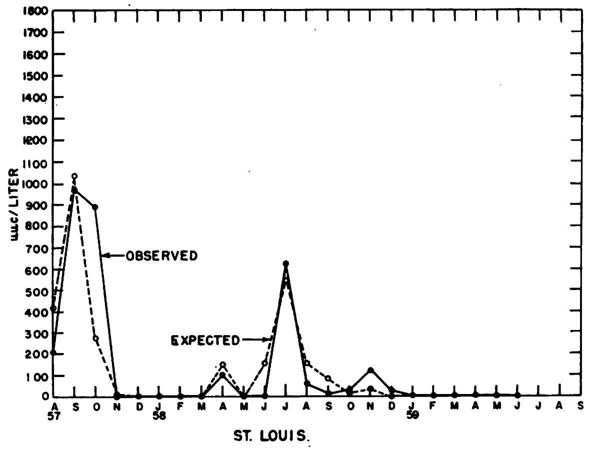
better agreement in Cincinnati and Salt Lake City, but it was poorer in New York. Generally similar results were obtained with barium 140, except that neither model worked well in Sacramento where the concentration of barium 140 never rose to a high level.

For iodine 131, the picture was somewhat different. Better agreement with observation was obtained using model 1a in the New York, Cincinnati, and Salt Lake City milksheds, but model 1 was better in St. Louis. Again both models fared badly in Sacramento, largely because of a complete failure to account for the high value observed in June 1958.

The charts show the goodness of fit of which-

Figure 3. IODINE 131: Observed and expected concentrations in samples of milk from specified milksheds, August 1957–September 1959





ever of these two models appeared best for each nuclide-milkshed combination. A quantitative summary, given in table 2, gives the proportion of overall variation in the data accounted for by the model fitted. Apart from the poor results for barium 140 and iodine 131 in the Sacramento milkshed, an average of about 74 percent of the observed variability in all three nuclides has been explained by models 1 or 1a, despite the rather gross assumptions and the crudeness with which such factors as weapons test yield and feeding practices have been estimated.

Extrapolating these models through the first 9 months of 1959 showed poor agreement with

strontium 89 data, as shown in figure 1. The trend is roughly parallel (except in Sacramento), but the predicted level is much too low. This may be due partly to an underestimate of the relative yield of the Soviet test series during October 1958. Martell and Drevinsky (*5*) estimated the yield of this series to be three to five times higher than that of any earlier Pacific test series conducted by the United States or the United Kingdom back to August 1956. The scoring applied in this paper has probably undervalued this Soviet contribution by a factor of 2. A truer weighting would have produced a fairly satisfactory extrapolated fit to the strontium 89 observations in New York and Salt Lake City, but expected values in Cincinnati, St. Louis, and Sacramento would still be too low. One possible explanation for the discrepancy in St. Louis is that a higher proportion of cows were on pasture during November and December 1958 than indicated in table 1.

Under the theory of Martell and Drevinsky, this substantial rise observed in strontium 89 during the spring of 1959 represents delayed fallout of surviving stratospheric activity produced by the Soviet test series of October 1958 and precipitated by spring rains. Its shifting appearance in milk, reaching a peak earlier in Cincinnati, St. Louis, and Sacramento than in New York and Salt Lake City, reflects differences among the milksheds in the proportion of cows on pasture during the early months of the year (see table 1). During the years 1956–58, characterized by many series of tests, delayed stratospheric fallout of strontium 89 from one series may have simply added to a more immediate tropospheric fallout fraction contributed by a later series. This would explain why model 1 or 1a described fairly well the strontium 89 data during this period but often fell short of very high concentrations. Data on barium 140 and iodine 131 during early 1959 indicate that these nuclides have either fallen out or decayed within the time allowed in the model.

Table 2. Percentage variation accounted for by models 1 or 1a

Nuclide	Milkshed				
	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento
Strontium 89 [1]	79	59	71	73	75
Barium 140 [1]	88	74	78	68	4
Iodine 131 [2]	66	97	69	60	4

[1] New York, model 1a; other cities, model 1.
[2] St. Louis, model 1; other cities, 1a.

The magnitudes of coefficients a_1 and a_2 in models 1 or 1a have no meaning in themselves since the variables X_1 and X_2 are dimensionless. However, ratios $a_2 : a_1$ for each nuclide may be compared from city to city. This comparison would indicate the relative importance of tests outside and those inside continental United States as contributors to the nuclide content of milk from different sheds. These ratios are listed in table 3. Only one general conclusion may be gleaned from this table, that is, the not unexpected finding that tests outside the United States have provided a relatively greater contribution to strontium 89 than to either barium 140 or iodine 131 activity in these milksheds, with the possible exception of Sacramento.

Turning to the simpler models, 2, 3, and 4, involving only monthly precipitation and the proportion of cows on pasture, table 4 shows the percentage variation explained by these formulas. With respect to strontium 89 data, all these models show substantially poorer agreement than does either model 1 or 1a except in Cincinnati. Here model 4 more faithfully reproduced the steep rise in strontium 89 from the Hardtack series during May–July 1958.

None of these simpler models succeeded in adequately describing barium 140 or iodine 131 concentrations. This was clearly due to the inability of broad, seasonal trends in feeding practices or random fluctuations in precipitation to cope with spikes of very short-lived radioactivity produced by specific groups of weapons tests.

Application to Strontium 90 and Cesium 137

For several reasons model 1 (or 1a) is not well suited to describing the monthly series of long-lived nuclide concentrations observed in milk. First, no allowance is made for long-delayed stratospheric fallout of these nuclides from

Table 3. Ratios of "outside" to "inside" test coefficients ($a_2 : a_1$) in model 1 or 1a

Nuclide	Milkshed				
	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento
Strontium 89	3.1	4.4	5.3	10.6	2.2
Barium 140	1.7	1.9	.8	6.2	------
Iodine 131	2.1	1.6	3.1	2.0	------

Table 4. Percentage variation accounted for by models 2, 3, and 4

Nuclide and model	Milkshed				
	New York	Cincinnati	St. Louis	Salt Lake City	Sacramento
Strontium 89:					
2	44	50	19	17	<10
3	58	62	42	56	34
4	55	74	38	62	58
Barium 140:					
2	<10	28	12	22	<10
3	30	31	16	18	<10
4	45	37	10	23	<10
Iodine 131:					
2	<10	<10	<10	<10	<10
3	<10	21	<10	<10	<10
4	28	15	<10	<10	<10

Pacific and Soviet tests. Second, it would be difficult to determine the relative contribution of earlier nuclear tests to long-lived nuclides currently available to cattle on pasture. Finally, in the absence of appreciable radioactive decay, model 1 must necessarily predict a monotonic increase in nuclide concentration. From August 1957 through May 1959, the trend of long-lived nuclide concentrations in milk has generally been upward (*1*, *2*), but downward fluctuations have occurred during many individual months. The model could not hope to reproduce these.

These objections are largely overcome or avoided in the simpler models. For example, the use of precipitation during the month of sample collection rather than the month of assumed fallout indirectly recognizes the importance of delayed fallout. Moreover, since these models fitted much better to strontium 89 data than to barium 140 or iodine 131, they might be expected to explain the observed variations in strontium 90 and cesium 137. Model 4, with the addition of a simple time trend, looks particularly promising. A later report will discuss the results of fitting this model to published concentrations of strontium 90 and cesium 137 in milk from a number of different milksheds.

Summary

Mathematical models have been developed and fitted to monthly observations of strontium 89, barium 140, and iodine 131 in milk samples from five milksheds serving large urban populations. The most complicated of these models (model 1) included the following factors: previous nuclear weapons tests, radioactive decay, monthly precipitation, and the proportion of cows on pasture each month. This model fitted reasonably well all series of data except those for barium 140 and iodine 131 in the Sacramento samples. It failed, however, to predict the high levels of strontium 89 observed during the spring of 1959 in the Cincinnati, St. Louis, and Sacramento milksheds. This was probably due partly to an undervaluation of the yield of Soviet nuclear tests in late 1958 and partly to delayed stratospheric fallout of strontium 89, an event which would be obscured during years of repeated series of tests.

Simpler models included only the last two of the four factors expressed separately or as a product. These models were far too rigid to describe the sudden peaks and dips in barium 140 and iodine 131 data. They did better with strontium 89 but not as well as model 1.

With respect to the long-lived nuclides, strontium 90 and cesium 137, certain objections may be raised to model 1 which are avoided or overcome in the simpler models. Further work with one of these models, modified by the addition of a simple time trend, should test its applicability to the series of long-lived nuclide concentration.

REFERENCES

(*1*) Campbell, J. E., et al.: The occurrence of strontium-90, iodine-131 and other radionuclides in milk, May 1957 through April 1958. Am. J. Pub. Health 49: 225–235, February 1959.

(2) Campbell, J. E., et al.: Radionuclides in milk. J. Agricultural & Food Chemistry 9: 117–122, March–April 1961.

(3) U.S. Congress, Joint Committee on Atomic Energy: Hearings before the Special Subcommittee on Radiation of the Joint Committee, May 5–8. 86th Cong. Washington, D.C., U.S. Government Printing Office, 1959, (a) vol. 2, pp. 972–977, (b) vol. 2, pp. 1290–1292.

(4) Telegadas, K.: Announced nuclear detonations. *In* Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, May 5–8. 86th Cong. Washington, D.C., U.S. Government Printing Office, 1959, vol. 3, appendix I, pp. 2517–2533.

(5) Martell, E. A., and Drevinsky, P. J.: Atmospheric transport of artificial radioactivity. Science 132: 1523–1531, Nov. 25, 1960.

(6) Comar, C. L., et al.: Thyroid radioactivity after nuclear weapons test. Science 126: 16–18, July 5, 1957.

PUBLICATION ANNOUNCEMENTS

Address inquiries to the publisher or sponsoring agency.

Better Communication for Better Health. 1961 National Health Forum, action highlight reports. 1961; 30 pages. National Health Council, 1790 Broadway, New York 19.

A Comparison of Automotive Crash Injury Research Samples With Complete State Data. By B. J. Campbell. February 1961; 14 pages. Automotive Crash Injury Research of Cornell University, 316 East 61st St., New York 21.

Learning More About Communication. By Irving S. Shapiro, Ph.D. 1961; 24 pages; $1. National Public Relations Council of Health and Welfare Services, Inc., 257 Park Ave., South, New York 10.

Helping Parents of Handicapped Children. Group approaches. 1961; 40 pages; $1.25. Child Study Association of America, 9 East 89th St., New York 28.

Science and Food: Today and Tomorrow. Summaries of papers presented at a symposium, December 8, 1960. 1961; 15 pages. National Academy of Sciences—National Research Council, Washington, D.C.

Science and Food: Today and Tomorrow. Proceedings of a symposium, December 8, 1960. Publication 877. 1961; 73 pages. Food Protection Committee, Food and Nutrition Board, National Academy of Sciences—National Research Council, Washington, D.C.

The National Library of Medicine Index Mechanization Project. July 1, 1958–June 30, 1960. Bulletin of the Medical Library Association, Vol. 49, No. 1, Part 2; January 1961. National Library of Medicine, Washington 25, D.C.

Alcoholism and California. Law Violators, Probation Status, and Drinking Involvement. A pilot study. Publication No. 4. 1961; 22 pages. California State Department of Public Health, 2151 Berkeley Way, Berkeley 4.

Chronic Disease Control. Continued Education Series No. 88. 1960; 211 pages; $3. The University of Michigan School of Public Health, Continued Education Service, 109 South Observatory St., Ann Arbor, Mich.

Facts About Blood Banking. 1961; 14 pages. American Association of Blood Banks, Central Office, 30 North Michigan Ave., Chicago 2.

The Cost of Social Security, 1949–1957. 1961; 238 pages; $3. International Labour Office, 916 15th St. NW., Washington 5, D.C.

World Health Organization

WHO publications may be obtained from the Columbia University Press, International Documents Service, 2960 Broadway, New York 27.

Molluscicides. Second report of the Expert Committee on Bilharziases. WHO Technical Report Series No. 214. 1961; 60 cents; Geneva.

Planning of Public Health Services. Fourth report of the Expert Committee on Public Health Administration. WHO Technical Report Series No. 215. 1961; 60 cents; Geneva.

Recommended Requirements for Schools of Public Health. Tenth report of the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel. WHO Technical Report Series No. 216. 1961; 30 cents; Geneva.

Public Health Aspects of Low Birth Weight. Third report of the Expert Committee on Maternal and Child Health. WHO Technical Report Series No. 217. 1961; 30 cents; Geneva.

Executive Board, Twenty-Seventh Session, New Delhi, 30 January–2 February 1961. Resolutions and annexes. Official Records of the World Health Organization, No. 108. May 1961; 44 pages; 60 cents; Geneva.

Financial Report, 1 January–31 December 1960. Supplement to the annual report of the Director-General for 1960 and Report of the External Auditor to the World Health Assembly. Official Records of the World Health Organization, No. 109. May 1961; 74 pages; 60 cents; Geneva.

Fourteenth World Health Assembly, New Delhi, 7–24 February 1961. Part 1. Resolutions and decisions and annexes. Official Records of the World Health Organization, No. 110. May 1961; 73 pages; 60 cents; Geneva.

Legal Note . . .
Zoning—Regulation of Nonconforming Uses

An ordinance regulating sand pit operations in a residential district which had the practical effect of precluding its continued operation as a "nonconforming" use held valid as exercise of police power where hazard to welfare existed. *Town of Hempstead* v. *Goldblatt et al.*, 9 N.Y. 2d 101, 211 N.Y.S. 2d 185 (1961).

The defendant appealed from a judgment of a lower court upholding the constitutionality of a town ordinance and enjoining the defendant from conducting a sand mining operation in the town until certain violations of the ordinance had been corrected and a permit obtained. The ordinance was attacked as confiscatory and in violation of the due process clause of the Federal and State constitutions.

In 1927 the defendant purchased 38 acres of land in a rural area and began to mine sand and gravel. When excavation went below water level, the defendant began dredging. In 1930, after dredging began, provisions for residential zoning were enacted by the town of Hempstead and thereafter the surrounding area became heavily populated. Within a radius of 3,500 feet of the pit were more than 2,200 homes, and 4 schools with an enrollment of 4,500. At the time of the suit, the dredging had created an artificial 20-acre lake with an average depth of 25 feet. The remainder of the plot was entirely occupied by defendant's machinery.

Pursuant to the requirements of a 1945 ordinance, the defendant enclosed the entire property with 7,000 lineal feet of a 6-foot chain-link fence topped by three strands of barbed wire. Other requirements of the ordinance governing the slope of the pit sides and the distance of the excavation from the property line were also complied with, so that although the business was a "nonconforming" use under the zoning ordinance, it operated in conformity with the 1945 ordinance until 1958 when the ordinance was amended.

The amended ordinance, in order to protect against the danger "of cave-ins, falls, drownings, and water pollution," made new provisions for setbacks, degrees of slope, barricade, fences, lights, retaining walls, and maximum ground water level for all open excavations. The defendant, who conducted the only sand and gravel mine in the town, would be required to lay a concrete curb beneath the existing fence, a requirement that could only be met by removing the fence, laying the concrete, and constructing a new fence.

It also prohibited excavation below water level or more than 10 feet below the highway level. Finally, it required the fill-in of all excavations not complying with these new requirements. To obtain a permit to continue business, the defendant would have to fill in approximately 1 million cubic yards of excavation, at a cost of more than $1 million.

The defendant argued that the ordinance was invalid since it was in essence a retroactive zoning ordinance calculated to destroy a substantial investment in the mining operation, which was a pre-existing nonconforming use.

This argument was rejected by a four-to-three decision of the New York Court of Appeals. Noting that the 1958 amendments did not prohibit the continuance of sand mining as a nonconforming use under the zoning ordinance, the court, taking into account the location of the pit in a heavily populated area, held it to be an appropriate regulation of a dangerous situation, declaring: "The hazards to both life and property accompanying the uncontrolled operation of these pits are common knowledge, and their restraint need not await an event."

An ordinance, such as here involved, which is an exercise of statutorily delegated police power, is not to be held invalid as a matter of law, said the court, "unless there is no justification on 'any state of facts'." On the record, there was a reasonable apprehension of a threat to the community's welfare. The "reasonableness, wisdom and propriety" of the ordinance, under these circumstances, was for the legislators, not the courts, to determine.

In discussing the scope of the police power, the court quoted with approval the statement that this power is "one of the most essential powers of govern-

ment, one that is the least limitable. . . . A vested interest cannot be asserted against it because of conditions once obtaining. To so hold would preclude development and fix a city forever in its primitive conditions."

Finding a rational basis for the ordinance, the court sustained its constitutionality and upheld the judgment appealed from.

Comment: This four-to-three decision emphasizes the broad sweep of the police power before which even substantial private interests must yield. As pointed out in the dissenting opinion, the "regulatory" ordinance imposed conditions on the defendant's use of his property for sand mining which effectively precluded the continuance of this nonconforming use, a result which could not have lawfully been achieved by a zoning ordinance.

Note: Defendant's application for review of the judgment was approved by the U.S. Supreme Court which noted probable jurisdiction on June 5, 1961 (29 L.W. 3366). The case will probably be heard in the fall term of the Court.—SIDNEY EDELMAN, *assistant chief, Public Health Division, Office of General Counsel, Department of Health, Education, and Welfare.*

Early Infectious Syphilis Increases

The 4,508 cases of early infectious syphilis reported for the quarter year July–September 1960 represent a 72.2 percent increase for the same quarter of the previous year. This is the sharpest rise in infectious syphilis ever reported in the United States within so short a time.

Health officials of 24 States and 48 major cities consider the rise in syphilis morbidity to be essentially an increase in the rate of occurrence. Although improved casefinding and better reporting are factors, health officials think that these alone would not have produced the sharp increases noticeable in widely separated cities this year.

A substantial number of States and cities are conducting studies of morbidity reporting among private physicians. Fifteen States and 24 cities report such studies. Private physician reporting of early infectious syphilis improved somewhat over the past year. The number of States reporting increase in private physician reporting was 28 compared to 25 last year, and the number of cities was 46 compared to 27.

Between 1957 and 1959 there has been a steady increase in the number of venereal disease cases reported among persons 19 years of age and under: 48,964 in 1957, 53,881 in 1958, and 55,763 in 1959. There was a sharp increase in the number of cities reporting rise in infectious syphilis in ages 15 to 19 and 20 to 24. A year ago, 21 cities reported increases in early infectious syphilis among the 15- to 19-year group; this year, 31. A year ago 25 cities reported increase in early infectious syphilis in the 20- to 24-year group; this year, 38.

Thirty-nine States reported areas without adequate venereal disease control coverage. Among the areas named by States are 32 cities, 276 counties, and 5 other areas. The total population in the inadequately covered areas is 30,796,282. Lack of personnel is the major problem in the matter of inadequate coverage.

Schools in more than half the States and cities are teaching something in some course about venereal disease. In 26 States and 51 cities, public schools provide instruction that includes venereal diseases. In 24 States and 36 cities the public schools do not provide such instruction. In 19 States and 21 cities, parochial schools provide instruction that includes venereal diseases; in 26 States and 50 cities they do not.

Although 45 States and 87 cities make VD educational resources available to schools and other educational establishments, half of the States and over one-third of the cities were unable or did not attempt to provide information on course content.—*Excerpts from a joint statement by the Association of State and Territorial Health Officers, the American Venereal Disease Association, and the American Social Health Association, March 1961.*