Chapter 5

Cows' Milk Production, Utilization, Distribution and Consumption

Contents: The assessment of the radiation exposures resulting from the ingestion of ^{131}I contaminated cows' milk necessitates the estimation of the amounts and origins of the fresh fluid milk consumed by people. The production, utilization, and distribution of cows' milk in each county of the contiguous U.S. in the 1950s is derived from agricultural census data combined with the use of simple models. The consumption of milk is determined according to sex, age group, and region of the country from dietary surveys and population census data.

During the 1950s, about 50% of the cows' milk produced in the United States was consumed by the populace as fresh fluid milk (Judkins and Keener 1960), about 3% was used on farms to feed livestock, and the remainder was used in the manufacture of dairy products or other foods. Because of the half-life of ^{131}I and the time interval between milk production and the consumption of manufactured foods containing milk, these products are not considered to be a significant exposure route for ^{131}I. The most important dairy product of concern in the transport of ^{131}I to people via the food chain is fresh fluid milk. This is due to the relatively short time from its production to human consumption. In the remainder of the report, the terms "fluid cows' milk" and "cows' milk" mean fresh fluid milk that is obtained from cows and consumed by people.

Most of the cows' milk produced for consumption as fresh fluid milk is commercially distributed but some of it is consumed on farms. Knowledge of the movement of milk between the areas of production and consumption is necessary because milk originating in different locations will have varying ^{131}I concentrations as a result of the heterogeneous distribution of fallout deposition across the U.S. after each test. In addition, the greater the distribution distance of the milk, the greater the elapsed time between the production and the consumption of the fresh fluid milk, and, in turn, the greater the amount of decay of ^{131}I prior to human consumption.

Individual consumption rates of cows' milk vary according to a number of factors such as age, sex, race, year, geographical area, and degree of urbanization. These factors also need to be taken into consideration in the assessment of individual exposures to ^{131}I.

The methodology for relating the production, distribution and consumption of milk throughout the country is dependent upon a separate analysis of each component:

- the estimation of milk production on a county by county basis;
- the extent to which it was used for human consumption also called fluid use;
- the distribution of milk for fluid use between the site of production and the location at which it was consumed;
- the consumption rates of fresh fluid milk by various subgroups in the population.

Statistical data on amounts of milk produced or distributed are usually reported in the U.S. in units of pounds (or multiple of pounds) per year. They have been systematically converted in this report to liters per year, using a conversion factor of 2.205 pounds per liter of milk. Survey data on milk consumption are usually reported in fluid ounces; they have been converted to milliliters, using a conversion factor of 30 milliliters per fluid ounce.

5.1. COWS' MILK PRODUCTION

The production of milk in a given county can be estimated from county data published by the U.S. Department of Commerce in the Censuses of Agriculture (for example, USDC 1954) combined with state statistics published by the U.S. Department of Agriculture (USDA 1962a).[1] Censuses of Agriculture were conducted in 1950, 1954 and 1959. Since the most important NTS tests with regard to fallout were carried out in 1952, 1953, 1955, and 1957, and because changes in the dairy milk industry are relatively slow, data from the 1954 Census of Agriculture have been taken to be representative of the situation during the entire period of nuclear weapons testing in the atmosphere at NTS.

Assuming that the average milk production per cow reported for a state does not vary significantly from the average milk production rate in a given county in the same state, the total annual production of milk in a given county is estimated from the number of cows in that county (USDC 1954) and from the average annual milk production per cow in the state (USDA 1962a):

$$MP(i) = C(i) \times CP(s) \tag{5.1}$$

where:

MP(i) = rate of milk production in thousands of liters per year (kL y^{-1}) in a county

C(i) = number of cows in a county

CP(s) = average milk production (kL y^{-1}) per cow in the state.

The index i for all variables in this equation, as well as in the following ones, denotes the value for a given county while the index s, in this equation as well as in the following ones, denotes the value for a given state.

5.2. COWS' MILK UTILIZATION

The amount of milk produced in each county of the contiguous United States that is available for fluid use is estimated using:

$$TMFU(i) = MP(i) - MUF(i) - MM(i) \tag{5.2}$$

where:

TMFU(i) = rate of production of milk for fluid use (kL y^{-1}) in a county

MP(i) = rate of milk production (kL y^{-1}) in a county

MUF(i) = rate at which milk is used on the farm for purposes other than human consumption (kL y^{-1}) in a county

MM(i) = rate at which milk produced in a county is used for manufacture of food products (kL y^{-1}).

Milk that is used on farms for feeding calves and for butter production (referred to as "milk used on farms" in this report) in a given county is estimated by assuming that the number of cows on the farm was an important factor in the amount of milk used on that farm. To apportion the state value for the rate of milk use on farms, MUF(s) (kL y^{-1}), as reported by USDA (1962a), among the counties, the ratio of the number of cows in each county to the total number in the state was used:

$$MUF(i) = MUF(s) \times \frac{C(i)}{C(s)} \tag{5.3}$$

where:

MUF(i) = rate of milk use on the farms (kL y^{-1}) in a county

C(i) = number of cows in a county

C(s) = number of cows in a state.

The rates of milk usage in the states for the manufacture of dairy products, MM(s) were reported by the USDA (1962a), but data on the fraction of the milk produced in each county that was used for this purpose in the 1950s and 1960s are not available. Because milk for fluid use would have brought a higher price than would other dairy products (Beal and Baaken 1956), it can be assumed that only the surplus, after the consumption needs of the population of that county had been met, would have been sold, at a lower price, to manufacturing plants.

To estimate the rate of milk use for manufacture of dairy products in each county, it is assumed that in counties where more milk was produced than was needed for fluid use in that county, a portion of the milk produced was purchased by a local

[1] Personal communication (1986) with Robert Miller, Agricultural Marketing Service–USDA, Dairy Divison, Washington, D.C. 20250

or regional manufacturing plant. In each county with a milk surplus, the rate at which milk was used for the manufacture of dairy products, MM(i) (kL y^{-1}), is estimated from:

$$MM(i) = MM(s) \times \frac{MP(i)}{TMP(s)} \qquad (5.4)$$

where:

MM(s) = rate of milk usage for manufacture of food products (kL y^{-1}) in a state

MP(i) = rate of milk production (kL y^{-1}) in the county

TMP(s) = sum of milk production rates (kL y^{-1}) in all the counties with a milk surplus (as defined by DIF(i), shown below) in the state.

To determine the counties that had a surplus of milk production after farm use was taken into account, the following assessment was carried out:

$$DIF(i) = (MP(i) - MUF(i)) - EC(i) \qquad (5.5)$$

where:

DIF(i) = test value (kL y^{-1}) that provides indication of surplus or deficit of milk in a county

MP(i) = rate of milk production (kL y^{-1}) in the county

MUF(i) = rate of milk usage on the farms (kL y^{-1}) in the county

EC(i) = expected rate of milk consumption (kL y^{-1}) in the county (as defined below)

If the value of DIF(i) was positive, there was a surplus of milk in the county. If DIF(i) was negative, the county did not produce enough milk to meet the human consumption needs of its population and is considered to have a milk deficit. The expected consumption rate of fresh fluid milk for the population in the county is estimated using the per capita milk consumption for the state. Those rates and other milk production and usage data for each state are listed in *Table 5.1.*

The expected milk consumption rate for county i, EC(i), (kLy^{-1}), is:

$$EC(i) = POP(i) \times CR_{pc}(s) \times \frac{365}{10^6} \qquad (5.6)$$

where:

POP(i) = population of a county, i, in a state, s

$CR_{pc}(s)$ = per capita milk consumption rate (mL d^{-1}) in a state, s

365 = the number of days in a year

10^6 = the number of mL in a kL

The derivation of the per capita milk consumption rates for each state is discussed in **Section 5.4.**

The rate at which milk was used to make cheese and other products in each county with a surplus is estimated using *equation 5.4*. TMP(s) is determined by adding the amount of milk produced, MP(i), in each of the surplus counties where DIF(i), computed using *equation 5.5,* was greater than zero.

In some cases, due to the methodology, the estimated rate of milk use for manufacture in the county, MM(i), is greater than the rate of milk production in the county, MP(i), minus the rate of milk usage on the farms in the county, MUF(i). In the 55 counties where this occurs, MM(i) is limited to be equal to MP(i) minus MUF(i) minus the volume of milk consumed on the farms in the county, MCF(i) (discussed in **Section 5.3**).

It is difficult to verify these estimates because milk destined for use in the manufacture of dairy products was shipped across county and state boundaries (Meenen 1952) to operating plants and reported in terms of processing rates for specified types of plants. Comparisons of the locations of manufacturing plants (Meenen 1952; Feder and Williams 1954) to the estimated rates of milk for fluid use in the same county did not take into account the milk shipped from counties with no manufacturing plants.

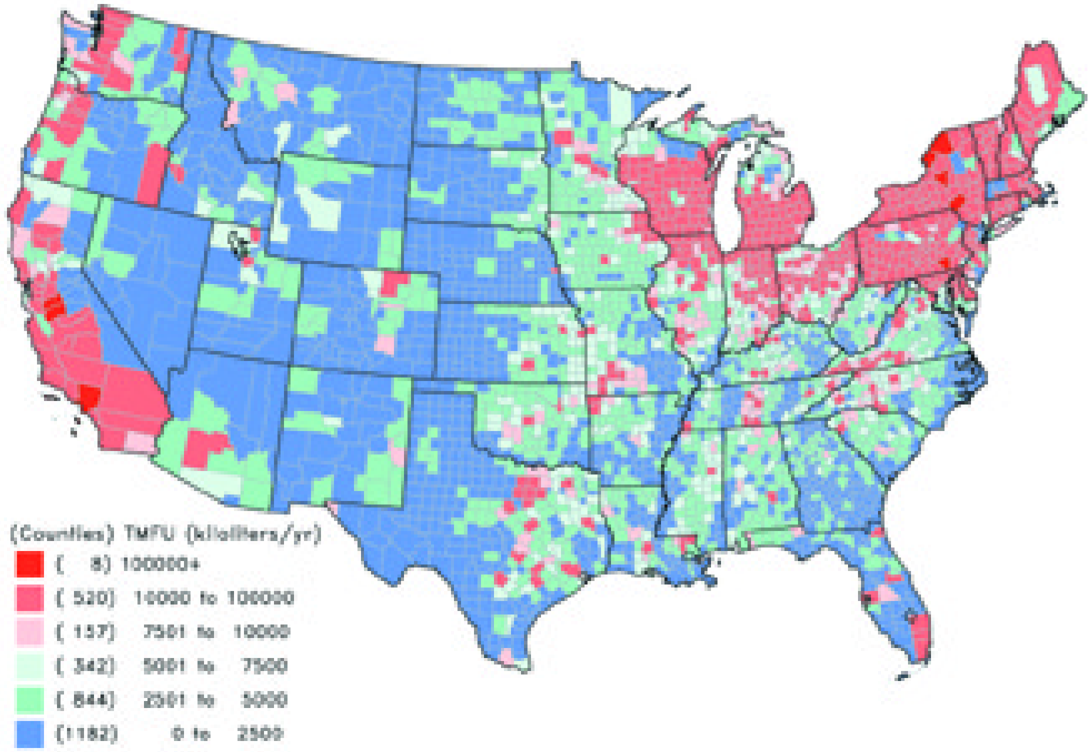
The estimates, calculated using *equation 5.2,* of the rate of production of milk for fluid use, TMFU, are given for each state in the contiguous U.S. in *Table 5.1.* The data for each county are presented in **Appendix 4** and the estimated values of TMFU(i) for each county in 1954 are illustrated in *Figure 5.1.*

Table 5.1. Summary of rates of production and usage of cows' milk in each state estimated for 1954. The units are in thousands of liters per year (kL y^{-1}) except for the consumption rates, $CR_{pc}(s)$, which are in milliliters per day (mL d^{-1}).

State	MP(s)[a]	MM(s)[b]	MUF(s)[c]	POP(s)[d]	$CR_{pc}(s)$[e]	EC(s)[f]	TMFU(s)[g]	MB(s)[h]
Alabama	473213	43705	106440	3148321	250	294365	257066	-37317
Arizona	130395	20465	5442	984400	300	107800	105066	-2732
Arkansas	469067	152971	90703	1857223	330	223701	245414	21713
California	3012305	1161390	60726	12790932	380	1769075	1769584	509
Colorado	393347	214062	27211	1527367	300	167243	122054	-45194
Connecticut	312003	57551	6017	2231603	445	362462	245641	-116040
Delaware	78700	6027	2721	372578	300	40957	60617	19660
Washington DC	0	0	0	769342	375	104707	0	-104707
Florida	331444	54043	10664	3697970	218	294064	265311	-28753
Georgia	466300	40683	121395	3658530	240	319774	319411	-362
Idaho	653814	533016	23025	622048	425	96496	97473	978
Illinois	2163712	1316665	72109	9294032	430	1458678	772916	-685761
Indiana	634656	714331	50794	4243799	430	666055	929733	263678
Iowa	2626051	2045024	100660	2679093	430	420478	481747	61269
Kansas	1027033	607937	73016	2021540	350	258253	340086	81834
Kentucky	1034745	486261	101134	2944011	350	386257	437331	49073
Louisiana	312332	51662	26116	2927348	250	273352	232332	-41020
Maine	269631	32109	24943	937355	445	152251	232779	80528
Maryland	596464	161769	16141	2685026	300	350166	416575	66367
Massachusetts	332716	90703	40616	4665201	445	759465	201136	-558269
Michigan	2235633	1006602	106576	6900071	430	1096057	1160001	63904
Minnesota	3767361	3221361	106122	3165830	450	519967	439879	-80108
Mississippi	631675	205605	123350	2178064	330	262416	302514	40098
Missouri	1661735	1101069	104762	4103847	330	495027	455865	-39142
Montana	234530	95236	22670	628021	500	114359	116077	2313
Nebraska	1012271	603796	66834	1360054	400	198660	133541	-65319
Nevada	30030	11973	2266	213263	302	23472	16395	-7078
New Hampshire	104340	13379	5690	594502	445	91700	145072	53372
New Jersey	465742	127120	3977	5356030	300	704140	348644	-355496
New Mexico	69814	16776	7250	785880	300	67150	63463	-23007
New York	4078437	1271740	127439	15053066	445	2445078	2077253	133075
N. Carolina	716716	130204	160091	4272000	275	428915	426421	-2293
North Dakota	632621	512653	64653	625030	500	114079	115116	1036
Ohio	2363033	1316317	93424	8084533	403	1290342	953356	-343025
Oklahoma	702000	321567	68461	2273712	330	273866	312592	38726
Oregon	536503	292290	31740	1620477	365	216067	214486	-2220
Pennsylvania	2563106	723537	93424	10847123	380	1504460	1772006	267727
Rhode Island	55016	13456	1361	820024	445	133231	34201	-99030
S. Carolina	254361	30703	53515	2229323	275	223432	170743	-53069
South Dakota	555216	357370	42177	664570	500	121263	155003	34080
Tennessee	1034512	437166	136506	3400015	330	410566	400815	-9773
Texas	1171570	200272	122303	8508450	290	900305	848404	-51902
Utah	263726	167631	12036	774016	300	84821	89136	4317
Vermont	731317	37914	13046	392315	445	62135	614350	552160
Virginia	655166	173901	121066	3593703	314	412163	554596	142413
Washington	780539	357007	43391	2560540	400	376759	379541	2782
W. Virginia	353977	73288	63033	1943923	275	195124	217651	22527
Wisconsin	7160037	5843312	263342	3654404	430	573551	1327363	753832
Wyoming	33390	35550	6017	304330	425	47209	49624	2415
TOTALS	51844384	26616288	3165080	162516736	372	22063284	22063028	-259

[a] MP(s) = Total milk produced
[b] MM(s) = Milk used for manufacturing
[c] MUF(s) = Milk used on farms (not consumed by people)
[d] POP(s) = Population
[e] $CR_{pc}(s)$ = Per capita consumption rate (mL/d)
[f] EC(s) = Expected consumption
[g] TMFU(s) = Total fluid milk consumed
[h] MB(s) = Surplus or deficit of milk (=TMFU(s) - EC(s))

Figure 5.1. Volumes of milk available for fluid use.



5.3. COWS' MILK DISTRIBUTION

In the distribution model, milk available for fluid use is either consumed on the farm, distributed for consumption to the local county population, or distributed to areas outside the county where the amount of available milk does not meet the consumption needs of the population. The distribution of milk to other counties usually results in the mixing of milk from a number of sources that may have varying ^{131}I concentrations as a result of differences in fallout deposition.

The way in which milk was collected and distributed in the United States during the 1950s was in a transitional period. More farmers employed bulk tanks to collect the milk, which increased the time between production and processing. During the 1950s the frequency of milk collection at the farm decreased from daily pick-up to every 3 days as the use of bulk tanks for collection and transportation of milk gradually replaced the use of individual milk cans (Beal and Bakken 1956; Henderson 1971; Roadhouse and Henderson 1950; Spencer 1957; USDA 1968a).

Milk, in general, was produced close to the population centers that required the milk supply (Lee 1950; Mighell and Black 1951), but the increasing use of refrigerated tank cars and the reduced cost of transportation also made it possible to ship milk greater distances. For example, although many of the experts surveyed during this study were of the opinion that milk was not routinely distributed more than 300 km away from the farm during the 1950s, there are reports that milk did flow greater distances (e.g., from the Midwest to New England and the East Coast) to satisfy major urban areas and to fulfill emergency shortages (Beal and Bakken 1956; Henderson 1971; Spencer 1957; USDA 1965). This also increased the amount of time between the processing and ultimate consumption of the milk by the population.

The factors that influence where bulk milk is purchased are: availability of surplus milk, price, transportation and handling charges, sanitary regulations, marketing regulations, and purchasing policies of the buyer (Carley 1964). The marketing of milk that was distributed long distances was loosely coordinated. Milk was purchased from farther distances when there was a need to fulfill a deficit. Emergency deficits of milk occurred on both a spot emergency (shortage of local supplies) and a seasonal basis (in most places September through February were lower milk production months). According to interviews conducted by Carley (1964), five out of 19 buyers bought milk from outside sources on a regular basis. They purchased milk from as many as 30 different sellers within a 4-year period starting in 1957. Routine contracts for long distance purchases did not allow for the flexibility needed by the purchasers, so they were not common.

Another factor that increased the time interval between production and consumption of the milk by the consumer was the decline of the total amount of milk delivered directly to the home during the 1950s. The frequency of the milk deliveries to homes also decreased (Henderson 1971).

Information on volumes and directions of milk distribution and on the delay times between production and consumption is, in general, more qualitative than quantitative. Although relevant data have been published for federally administered Milk Marketing Orders (USDA 1958) and for parts of the west (Ward and Whicker 1987), they do not provide all of the information required in this study and cannot be used to derive values for the entire country. It was therefore decided to resort to a simple model based on the nationwide statistics on milk production and utilization reported by the U.S. Department of Commerce (USDC 1954) and the U.S. Department of Agriculture (USDA 1962a), and to validate as much as possible the structure of the model and the assumptions used by means of published information and recollections of experts. Because of the complexity of the system and the associated uncertainties, it was decided to develop only one model of milk distribution for the 1950s and to use the 1954 data for that purpose.

In this model, the total milk for fluid use in a county, TMFU(i), is divided into four categories corresponding to the following population groups:

category 1: those living on the farms in the county where the milk is produced;

category 2: those living in the county where the milk was produced but not on farms;

category 3: those living in a group of neighboring counties within a designated "milk region", or group of neighboring counties in a state, and

category 4: those living at greater distances, that is, in other "milk regions" in the same or another state.

The model assumes that the milk produced in a county is used initially to satisfy the consumption needs within the county and, if there is a surplus, to fulfill the needs that have not been satisfied elsewhere. The volumes of milk that are assigned to each of the four categories are determined as follows:

Category 1. In order to estimate the portion of milk production in the county that was consumed on farms in that county, it is assumed that the consumption of milk on farms in a given county is proportional to the number of farms in that county. The total rate of milk consumption on farms in 1954 in the states, (USDA 1962b) is apportioned to the number of farms reported to be in each county in 1954, as follows:

$$MCF(i) = MCF(s) \times \frac{FA(i)}{FA(s)} \tag{5.7}$$

where:

MCF(i) = the rate of milk consumption (kL y^{-1}) on farms in a county, i

MCF(s) = rate of milk consumption (kL y^{-1}) on farms in the state, s

FA(i) = number of farms in a county, i

FA(s) = number of farms in a state, s

It is assumed that fresh fluid milk consumed on the farms would be consumed with a 1 day delay time between milk production and consumption.

In some cases, as a result of the methodology, the calculated amount of milk consumed on farms exceeded the calculated total expected milk consumption in the county. In these 37 counties, the amount of milk consumed on the farm was limited to the expected milk consumption in the county (i.e., it was assumed that all the milk consumed by the local population was consumed on farms).

Category 2. The source of milk consumed in a county but not on farms, is dependent on the amount of milk available in the county. The expected milk consumption rate for the county, calculated using *equation 5.6,* is subtracted from the total rate of milk production for fluid use available in the county. The result indicates whether the balance of milk in the county was surplus or deficit:

$$MB(i) = TMFU(i) - EC(i) \tag{5.8}$$

where:

MB(i) = milk balance (kL y^{-1}) in a county, i

TMFU(i) = rate of production of milk for fluid use (kL y^{-1}) in a county

EC(i) = expected rate of milk consumption (kL y^{-1}).

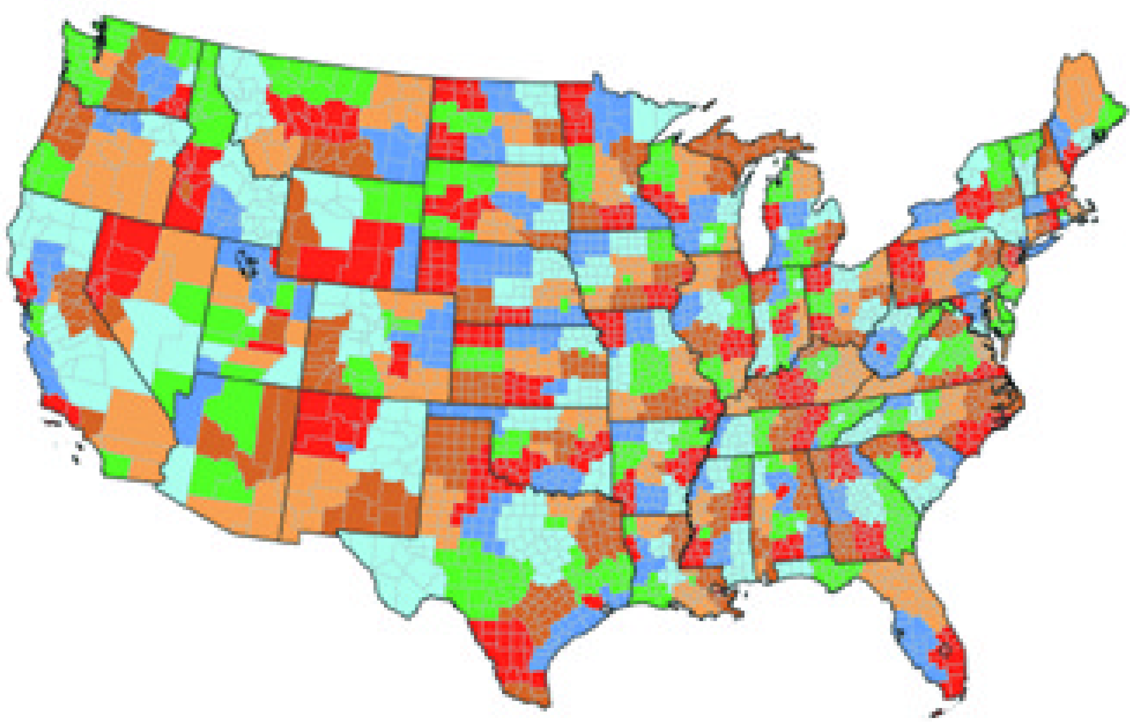
If MB(i) is positive, indicating a surplus of milk, the rate of category 2 milk use is equal to the rate of milk consumption on farms subtracted from the expected human milk consumption rate in the county, EC(i) - MCF(i). Any surplus milk remaining, MB(i), is exported to other counties. If MB(i) is negative, indicating a deficit, the rate of category 2 milk use is equal to the rate of milk consumption on farms subtracted from the rate of production of milk available for fluid use in the county, TMFU(i) - MCF(i). The remainder of milk needed to supply the population in this county is imported from other counties. Category 2 milk is in all cases assigned a delay time of 2 d between production and consumption.

Category 3. To simulate flow of milk over short distances, neighboring counties have been grouped into 429 "milk regions" that have been defined throughout the contiguous United States. The geographic extent of the regions are based on the Crop Reporting Regions and milkshed areas outlined by each state's Department of Agriculture (e.g., Pennsylvania Crop Reporting Service 1980). Additional regions were drawn to isolate the population concentrated around cities in each state. For the states close to the NTS (Nevada, Arizona, Utah, and part of California), available information on milk distribution and pasture practices (Ward and Whicker 1987) were used to designate boundaries of the milk regions. *Figure 5.2* illustrates the grouping of northeastern counties into milk regions. The milk regions for each state in the contiguous U.S. can be found in **Appendix 5.** Each milk region has been assigned an individual number.

The first step to balance the surplus (or deficit) of milk in an individual county is by flow of milk between counties in the same "milk region". The milk pooled from the counties with a surplus of milk is distributed to the counties of the region with a deficit of milk, proportionate to their needs. This rate of milk transfer to deficit counties within the region, constitutes the milk of category 3, to which a delay time of 3 d is assigned. Methods for calculating these transfer rates are given in **Chapter 6.**

Category 4. If the county surpluses of milk in the region does not meet the deficits in other counties, additional milk must be provided by another milk region. Milk of category 4 is that which is imported into a deficit region from another surplus region or, conversely, that which is exported from a surplus region into a deficit region. Milk in this category is assumed to have a delay time of 4 d between production and consumption because it has travelled the greatest distance from producer to consumer. Movements of milk in category 4 between surplus regions and deficit regions were designed to achieve balance between production and consumption at the national level. These transfer patterns are discussed in more

Figure 5.2. Identification of the "milk regions" used in the dose assessment.



[2] Personal communication (1987) with Geoffry Benson at North Carolina State University, Dairy Managing and Marketing, Raleigh, North Carolina.

Figure 5.3. The "milk regions" that provide their surplus milk to satisfy the milk deficit in the metropolitan New York area.

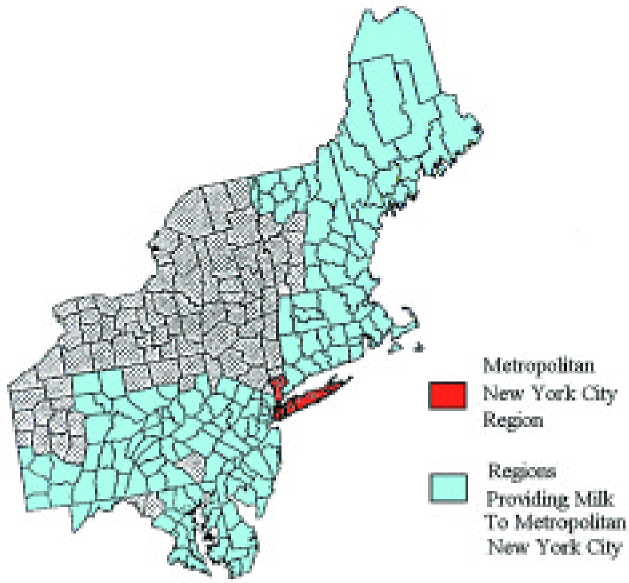
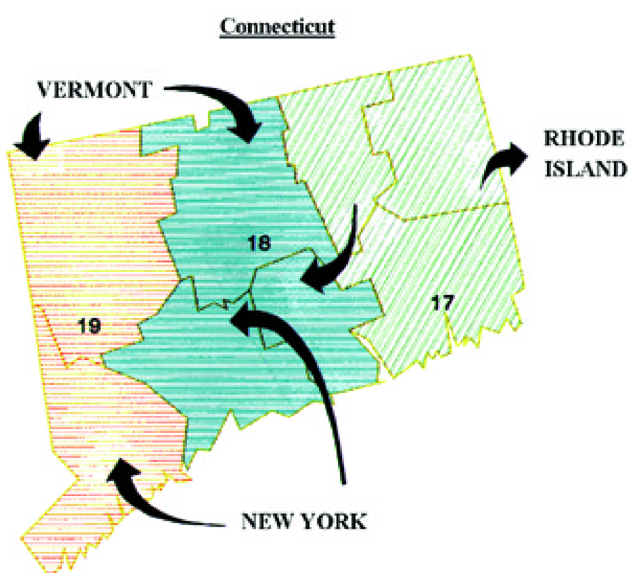


Figure 5.4. Transfer of milk to and from the milk regions of Connecticut in the 1950s, based on data from USDA (1958).



detail in **Chapter 6**.

The assumptions regarding the direction and distance that milk was distributed during the 1950s are based upon Agricultural Research Stations reports as well as information made available from State Agricultural Department Milk Boards, Federal Milk Marketing Administrators Offices, and Agricultural Economists with the Extension Service. Major patterns of milk flow in the U.S. were and are driven by the overall surplus and deficits calculated for each region of the country as a result of the needs of major population areas. The fact that most of the surplus milk in the U.S. is produced in the northern parts of the country and shipped south also had an important influence.[2]

In this study the direction of the distribution of milk was determined largely by using the data supplied by the USDA on the sources of milk for the Milk Marketing Orders operating in the U.S. in 1958 (USDA 1958). In some cases, individual reports from the marketing orders were available for the time in question. Unfortunately, there was very little consistency in the reporting of the sales and distribution of milk in the different orders, thereby making it almost impossible to use the volumes of milk reported. The volumes of milk that were distributed between regions in this model were determined by the surplus and deficits calculated, and the direction of the flow was heavily influenced by the data reported by the USDA (1958).

As an example of the use of these data, the milk regions supplying milk to the metropolitan New York City region are outlined in *Figure 5.3*. For the sake of clarity, other deficit regions in the Northeast such as those including Boston, Washington D.C., Philadelphia and Pittsburgh, are not illustrated in *Figure 5.3*. Regions producing surplus milk may supply milk to more than one deficit region and regional representation such as in *Figure 5.3* would become very complex if milk movements to all deficit areas were included. A simple example of milk flow between regions is illustrated in *Figure 5.4* for the state of Connecticut.

The rates of milk transfer between all regions in the contiguous United States are listed in **Appendix 5.** For each transfer of milk between two regions, there is an indication of the source of the distribution information and an indication of the degree of confidence in the data. If there were data available that showed that one or more counties in a given region were a source of milk for a Milk Marketing Order, the transfer data was considered to be the most reliable (level 1). There are many parts of the U.S. where milk sales were not administered using Milk Marketing Orders. In these cases, distribution between nearby regions also was judged to be fairly reliable (due to the assumption that milk was used close to the source first) (level 2). If the surplus region was not included in the sources of milk for the Milk Marketing Order but a transfer was made in this study, it was considered to be less certain that milk moved in that direction (level 3). This level of uncertainty is also considered appropriate for distribution patterns between non-adjacent counties that seem logical but for which there is no information available.

5.4. COWS' MILK CONSUMPTION

Individual consumption rates of fluid cows' milk vary widely according to age, sex, race, urbanization and area of the country, among other factors. Per capita milk consumption rates for large population groups, as reported by different sources, also vary significantly, primarily because the data were collected to satisfy various objectives, resulting in differences in populations surveyed, definitions of fluid milk for consumption, methods of data collection, and the year of the survey.

The per capita consumption rate of fluid cows' milk for the entire population of the United States can be inferred from USDA statistics on the total amount of milk sold for fluid use in the country (USDA 1962b). From the 1950s to date, the per capita milk consumption in the U.S. has decreased substantially, but most of this change has occurred since 1965. Between 1950 and 1965, the per capita milk consumption rate varied within a relatively narrow range, from the highest rate of 383 mL d^{-1} in 1956 to the lowest rate of 334 mL d^{-1} in 1965 (USDA 1968b).

Variations from the consumption rate for the whole population are seen as a function of age, sex, region of the country, race, season, and degree of urbanization (city vs country lifestyles). In this assessment, the factors of age, sex and region of the country were taken into account in determining the per capita consumption rates for each state *(Table 5.1)*. The other factors are discussed briefly. The statistical data used are, as much as possible, for the year 1954, taken as representative of the time period during which atmospheric weapons tests were carried out at the NTS.

5.4.1. Variation as a Function of Sex and Age

Variation of milk consumption rates as a function of sex and age have been reported by many authors (Durbin et al. 1970; PHS 1963a; PHS 1963b; Rupp 1980; Thompson 1966; Yang and Nelson 1986). The variation as a function of age is particularly important for infants.

Infants (0 to 1 year). The source and amount of milk consumed by infants changes significantly during their first 6 months (Durbin et al. 1970). Infants may consume mothers' milk, fluid cows' milk, evaporated milk, or ready-to-use formula. The fractions of the population of infants consuming mothers' milk and fluid cows' milk (types of milk contaminated with fallout ^{131}I) are presented in *Table 5.2*. The number of infants consuming mothers' milk decreases continuously as a function

Table 5.2. Variation with age of the fraction of infants drinking fluid cows' milk or mothers' milk for the years 1953 to 1962. Remainder of the infants consumed evaporated milk or ready-to-use formula (Durbin et al. 1970).

Year	Month										
	033	1	2	3	4	5	6	7	8	9	10
	(a) fraction of infants drinking fluid cows' milk										
1953	0.04	0.09	0.18	0.25	0.41	0.54	0.69	0.83	0.90	0.96	1.0
1954	0.04	0.08	0.17	0.25	0.41	0.55	0.69	0.83	0.90	0.96	1.0
1955	0.04	0.08	0.17	0.25	0.41	0.55	0.69	0.83	0.90	0.96	1.0
1956	0.04	0.08	0.17	0.25	0.41	0.56	0.69	0.83	0.90	0.96	1.0
1957	0.04	0.07	0.16	0.25	0.41	0.57	0.70	0.83	0.90	0.96	1.0
1958	0.04	0.05	0.15	0.24	0.42	0.56	0.69	0.83	0.90	0.96	1.0
1959	0.03	0.05	0.10	0.23	0.42	0.57	0.71	0.84	0.91	0.97	1.0
1960	0.03	0.05	0.10	0.25	0.44	0.58	0.72	0.87	0.97	0.98	1.0
1961	0.03	0.05	0.11	0.22	0.39	0.54	0.70	0.87	0.98	1.0	1.0
1962	0.02	0.05	0.11	0.20	0.38	0.56	0.72	0.88	0.98	1.0	1.0
	(b) fraction of infants that are breastfed										
1953	0.30	0.25	0.15	0.12	0.08	0.06	0.04	0.02	0.01	0	0
1954	0.30	0.25	0.15	0.12	0.08	0.06	0.04	0.02	0.01	0	0
1955	0.29	0.25	0.15	0.12	0.08	0.06	0.04	0.02	0.01	0	0
1956	0.29	0.22	0.15	0.12	0.08	0.06	0.04	0.02	0.01	0	0
1957	0.29	0.22	0.15	0.12	0.08	0.06	0.04	0.02	0.01	0	0
1958	0.29	0.22	0.15	0.12	0.08	0.06	0.04	0.02	0.01	0	0
1959	0.27	0.20	0.14	0.11	0.08	0.06	0.04	0.02	0.01	0	0
1960	0.27	0.20	0.14	0.11	0.08	0.06	0.04	0.02	0.01	0	0
1961	0.27	0.20	0.14	0.11	0.08	0.06	0.04	0.02	0.01	0	0
1962	0.27	0.20	0.13	0.13	0.08	0.06	0.04	0.02	0.01	0	0

Table 5.3. Variation of the per capita consumption of milk of all types and of fluid cows' milk according to age during the first year of age.

Age (month)	Per capita consumption of milk of all types[a] ($mL\ d^{-1}$)	Average fraction consuming fluid cows' milk[b]	Per capita consumption of fluid cows' milk[c] ($mL\ d^{-1}$)
1st	671	0.08	54
2nd	742	0.17	126
3rd	726	0.25	182
4th	742	0.41	304
5th	769	0.55	423
6th	790	0.69	545
7th	718	0.83	596
8th	718	0.90	646
9th	718	0.96	689
10th to 12th	689	1.0	689

[a] Derived from Durbin et al. (1970), Table 1. [b] Data from Table 5.2 for 1954. [c] Product of columns two and three of this table.

of age while, on the contrary, the number of infants consuming fluid cows' milk increases continuously. Fifty percent of infants drink cows' milk by the time they are 5 months old. The data for 1954 in *Table 5.2* were combined with infant consumption rates obtained in household consumption surveys to derive the infant per capita consumption rates of fresh cows' milk during the first year of age (*Table 5.3*). Total milk consumption rates for infants 4 months and older presented in *Table 5.3* were taken from Beal (1954) as published in Durbin et al. (1970). Beal's values for infants under 4 months appear to be at the lower end of the range reported; therefore, for the first 3 months the average of the consumption rates reported for infants consuming milk and some solid food (Beal 1954; Durbin et al. 1970; Filer 1968; Filer and Martinez 1963, 1964; Kahn et al. 1969) are reported in *Table 5.3*. Averaged over the entire population, the total milk consumption reaches a maximum at 6 months of age (790 mL d^{-1}). Consumption of cows' milk is highest during the ninth month (689 mL d^{-1}). Milk consumption during the first year is assumed to be the same for males and for females.

Children (> 1 y) and adults. The fraction of each age group consuming various amounts of milk on an average day was estimated in a household food consumption survey (PHS 1963a) conducted in July of 1962. About 28,000 persons throughout the contiguous United States were interviewed. Two experimental techniques were used: in one subsample, a 3-day recall interview was used; in the other subsample, a 1-day recall interview was conducted and the respondent was asked to maintain a diary for a 3-day period. The results are presented in *Table 5.4*.

The data presented in *Table 5.4* were used by Thompson and Lengemann (1965) to derive the per capita milk consumption rates for the age and sex classes reported in *Table 5.5*. *Table 5.5* presents the consumption rates for ages 1-y and older taken from Thompson and Lengemann (1965), along with data for infants, taken from *Table 5.3*. The data for both age groups obtained from the survey include only consumption of fresh fluid cows' milk. *Table 5.5* includes an increase in milk consumption of 237 mL d^{-1} for school age children, 5 to 19 years, participating in the school milk program (Downen 1955; Thompson and Lengemann 1965). The average per capita fresh cows' milk consumption rates, presented in *Table 5.5,* show a maximum for teenage boys and lower values during adulthood, with a minimum for middle-aged women. Beyond the first year of age, males on average consume more milk than females.

Per capita milk consumption rate for the U.S. population. The per capita fresh cows' milk consumption rate for the U.S. population is obtained by weighting the milk consumption values of *Table 5.5* with the corresponding population fractions in 1954. The population fractions were calculated using a database, provided by the U.S. Environmental Protection Agency (USEPA 1985), in which the populations of each county are listed according to race (white and non-white), sex, and 5-y age group, for each year between 1951 and 1980. *Table 5.6* presents the U.S. population fractions for 1954 according to sex and 5-y age group. Using the milk consumption data of *Table 5.5* and the population data of *Table 5.6,* and assuming that the population fraction for children less than 5 years old applies to both the 0-1 and 1-4 age groups, the per capita fluid cows' milk consumption rates for the U.S. male and female populations and for the entire U.S. population have been calculated. The results are presented in *Table 5.5.* The per capita fluid cows' milk consumption rate

Table 5.4. Percentage distribution of "at home" consumption of whole milk by age and sex - July 1962 (PHS 1963a).

Age	Milk Consumption Rate (mL d^{-1})											
(years)	None	30-119	120-239	240-359	360-479	480-599	600-719	720-839	840-959	960-1079	1080-1200	>1200
MALES												
All ages	32.1	5.7	7.8	11.6	5.9	10.0	4.2	7.6	2.7	6.8	1.3	4.2
under 1	38.0	0.1	1.9	1.4	2.7	4.1	4.2	10.7	5.3	20.4	1.3	9.9
1-4	15.9	1.6	5.1	8.9	10.4	14.2	7.6	14.5	4.7	11.0	1.9	4.3
5-9	20.5	1.3	5.3	10.2	8.3	12.9	7.1	15.1	4.7	8.6	1.8	4.2
10-14	25.0	1.4	4.6	8.6	6.8	10.3	6.7	11.3	5.2	10.2	1.7	8.1
15-19	28.9	2.6	4.9	8.8	5.7	9.3	4.1	9.1	3.0	10.0	3.0	10.5
20-24	35.1	4.1	6.7	14.7	4.4	10.8	3.4	4.6	2.3	6.9	1.5	5.3
25-29	39.1	7.5	7.6	11.0	5.8	10.5	1.7	6.2	2.2	4.5	0.6	3.2
30-34	37.5	9.8	9.1	14.4	5.7	8.0	3.2	4.6	1.1	4.5	0.4	1.7
35-44	39.1	10.4	9.4	13.4	4.6	8.5	2.8	4.0	1.2	4.0	0.8	1.7
45-54	42.0	9.5	11.0	13.7	4.4	7.1	1.9	2.8	1.1	3.4	0.5	2.5
55-64	40.9	8.4	11.2	13.2	4.1	9.5	2.5	2.8	1.1	3.1	0.8	2.4
65+	35.4	8.2	12.8	15.8	4.5	10.1	2.5	3.5	1.2	4.0	0.6	1.5
FEMALES												
All ages	37.9	6.8	9.9	13.1	6.3	9.0	3.4	5.6	1.6	4.1	0.6	1.6
under 1	41.2	0.5	1.1	3.2	2.3	4.5	3.4	9.6	5.7	20.5	1.5	6.5
1-4	17.3	1.1	7.2	10.2	11.1	12.0	7.9	12.6	4.1	10.9	1.7	3.9
5-9	23.6	1.6	6.9	11.5	9.9	13.9	7.2	11.5	2.9	6.8	1.2	3.0
10-14	32.3	2.1	5.6	12.3	7.1	11.2	6.3	10.3	3.1	5.4	1.4	2.8
15-19	39.4	4.0	6.4	13.0	6.3	10.1	4.1	7.2	1.7	5.1	0.6	2.1
20-24	42.8	6.6	7.9	17.2	6.5	7.8	2.3	4.6	1.1	2.1	0.3	0.9
25-29	43.1	10.2	9.9	14.6	5.0	8.2	1.5	2.6	1.3	2.1	0.6	0.8
30-34	43.9	12.3	11.7	14.7	4.3	7.0	1.2	2.3	0.9	1.0	0.2	0.5
35-44	45.3	11.8	12.5	12.2	5.0	6.7	1.6	2.5	0.5	1.5	0.1	0.4
45-54	46.2	9.9	12.3	15.6	4.3	6.0	1.8	1.6	0.2	1.5	0.2	0.3
55-64	45.1	9.3	14.0	13.1	4.9	7.2	1.0	2.2	0.5	1.7	0.2	0.7
65+	39.6	8.2	15.2	15.1	5.2	9.5	1.5	2.4	0.0	2.4	0.2	0.6

Table 5.5. Per capita consumption rates of fluid cows' milk by the U.S. population by age and sex[a].

Age		Consumption rate (mL d^{-1})		
year	month	male		female
	1st		54	
	2nd		126	
	3rd		182	
	4th		304	
	5th		423	
	6th		545	
	7th		596	
	8th		646	
	9th		639	
	10th to 12th		639	
1-4		530		503
5-9[b]		716		684
10-14[b]		747		619
15-19[b]		747		530
20-24		352		213
25-29		293		192
30-34		263		166
35-44		243		160
45-54		228		154
55-64		240		169
65+		246		192
All ages[c]		410		318
Per capita			364	

[a] Sources: Table 5.4 for (0 - 1)-y old infants; Thompson and Lengemann (1964) for all other age groups.

[b] For school age children an additional 23.7 mL per day of milk has been added to account for the School Milk Program (Thompson and Lengemann 1965).

[c] Calculated from the age and sex distribution of the U.S. population in 1954 (Table 5.6).

Table 5.6. Distribution of the U.S. population in 1954 (USEPA 1985).

Age (years)	Population		Population fraction	
	Male	Female	Male	Female
0-4	9,125,929	8,804,507	0.056	0.054
5-9	7,900,225	7,633,600	0.049	0.047
10-14	6,877,552	6,644,760	0.042	0.041
15-19	5,873,326	5,849,395	0.036	0.036
20-24	5,464,362	5,728,013	0.034	0.035
25-29	5,700,503	5,958,170	0.035	0.037
30-34	5,718,862	5,981,822	0.035	0.037
35-39	5,756,379	6,014,770	0.035	0.037
40-44	5,327,654	5,469,732	0.033	0.034
45-49	4,879,777	4,959,519	0.030	0.030
50-54	4,386,275	4,452,765	0.027	0.027
55-59	3,841,355	3,901,531	0.024	0.024
60-64	3,195,719	3,324,021	0.020	0.020
65+	6,522,077	7,570,729	0.040	0.046
TOTAL	80,569,992	82,293,328	0.495	0.505

for the U.S. population, CR_{pc}(US), is found to be 364 mL d^{-1}.

This figure, in agreement with that obtained from USDA statistics on the total amount of milk sold for fluid use in the country (372 mL d^{-1} in *Table 5.1*), is used in this assessment as the representative value of the per capita milk consumption rate for the U.S. population over the period of nuclear weapons testing in the atmosphere.

5.4.2. Variation as a Function of the Region of the Country

Per capita milk consumption rates, for the human population in different areas of the country, were reported in the USDA Household Food Consumption Survey conducted in 1955 as 477 mL d^{-1} in the northeast, 389 mL d^{-1} in the south, 520 mL d^{-1} in the northcentral and 488 mL d^{-1} in the western states (USDA 1955). This survey collected information on food consumption for 1 week during April or May from approximately 6000 households in the U.S. These values are thought to be overestimates because if the consumption rate were maintained throughout the year, the total amount of milk for fluid use reported for 1955 could not satisfy these consumption rates. This difference could be due to the inherent drawbacks of assuming that data collected for 1 week is representative of the whole year (Thompson and Lengemann 1965). The variations in milk consumption in different areas of the country are influenced by urbanization, race, climate and the percentage of the population not drinking any milk. This last point is shown in *Table 5.7,* which shows the percentage distribution of the at home daily consumption of milk by region. On an average day, about 30% of the people surveyed throughout the country did not drink any milk at all. *Table 5.7* also shows that the milk consumption rate in the South was substantially lower than in the North East, the North Central, or the West.

Estimates of per capita milk consumption rates assigned for the population of each state are presented on *Table 5.1.* These values, which are based on the regional milk consumption rates reported in various reports (USDA 1955; Thompson and Lengemann 1965) were adjusted according to the available amount of milk in each state and the milk distribution data.

Table 5.7. Percentage distribution of "at home" consumption of whole milk by sex and area[a] of U.S., July 1962 (PHS 1963[b])

Area	Milk Consumption Rate ($mL\ d^{-1}$)[b]											
	None	30-119	120-239	240-359	360-479	480-599	600-719	720-839	840-959	660-1079	1080-1200	>1200	mean[c]
MALE													
Northeast	21.7	8.3	8.6	12.7	5.7	10.4	4.0	9.4	3.3	9.0	1.5	5.4	446
North Central	27.8	6.0	9.0	10.5	7.4	10.0	5.0	7.6	4.0	6.1	1.6	5.0	412
South	42.4	5.0	6.7	12.3	5.1	9.0	3.3	6.2	1.6	5.2	0.7	2.4	295
West	34.8	2.2	6.7	10.5	5.7	11.2	4.8	7.8	1.9	8.1	1.5	4.8	400
FEMALE													
Northeast	26.0	10.3	11.6	13.1	7.3	9.9	3.6	7.4	2.0	6.1	0.9	1.8	335
North Central	34.9	7.0	11.3	12.9	7.1	8.8	4.4	5.2	2.0	3.5	0.8	2.1	291
South	48.0	5.4	8.1	13.7	4.8	7.9	2.3	4.3	1.1	3.0	0.3	0.9	214
West	42.1	3.7	8.3	12.2	6.2	10.1	3.3	6.4	1.0	4.2	0.6	1.8	276

[a] Areas of the country that were surveyed included 42 states:
Northeast included: the states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.
North Central included: the states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.
South included:the states of Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.
West included: the states of Arizona, Oregon, Utah, Washington, and Wyoming.

[b] The original values are reported in ounces per day. They have been converted to mL per day using a conversion factor of 30 mL per ounce of milk.

[c] Volume-weighted mean.

5.4.3. Other Factors

The dose assessment takes into account the variation of the milk consumption rate as a function of age, sex, and region of residence. Other factors which are known to influence the milk consumption rate to some extent not considered are:

- the season of the year,
- the degree of urbanization, defined very loosely in most surveys as living in cities versus rural living, and
- race.

The influence of the season on milk consumption is reported to have only a slight effect, on average, over a large population (Jeffrey 1957). *Figure 5.5* illustrates that the milk production in the northeastern U.S., in 1954, varied significantly during the year, but the human consumption rates did not.

The effect of urbanization on milk consumption rate is shown in *Table 5.8*. On average, people on farms consumed 30% more milk than people living in urban areas. It also is worth noting that the milk consumed on farms was predominately of local origin. Only 10% was purchased at a store as compared to the U.S. average person purchasing 81% at the store. In this assessment, the volume of milk consumed on farms in each state in 1954 is taken from USDA statistics (USDA 1962a).

Differences between the consumption rates of Black and White populations are illustrated in a report on milk consumption in urban North Carolina (Cotton 1950), where the per capita milk consumption for Whites was about 2.8 times greater than for Blacks (273 mL d^{-1} vs. 99 mL d^{-1}) during the late 1940s. One reason cited for these differences was thought to be due to the disparity in the income between the races. In general, in the 1950s, the Black population in the U.S. lived in certain regions of the country, and therefore the difference in milk consumption rates between Blacks and Whites is at least partly reflected in regional variations. These show, for example, a much lower per capita consumption of milk in the South Atlantic States than in New England.

Figure 5.5. Monthly use of market milk in the Northeast, 1954.

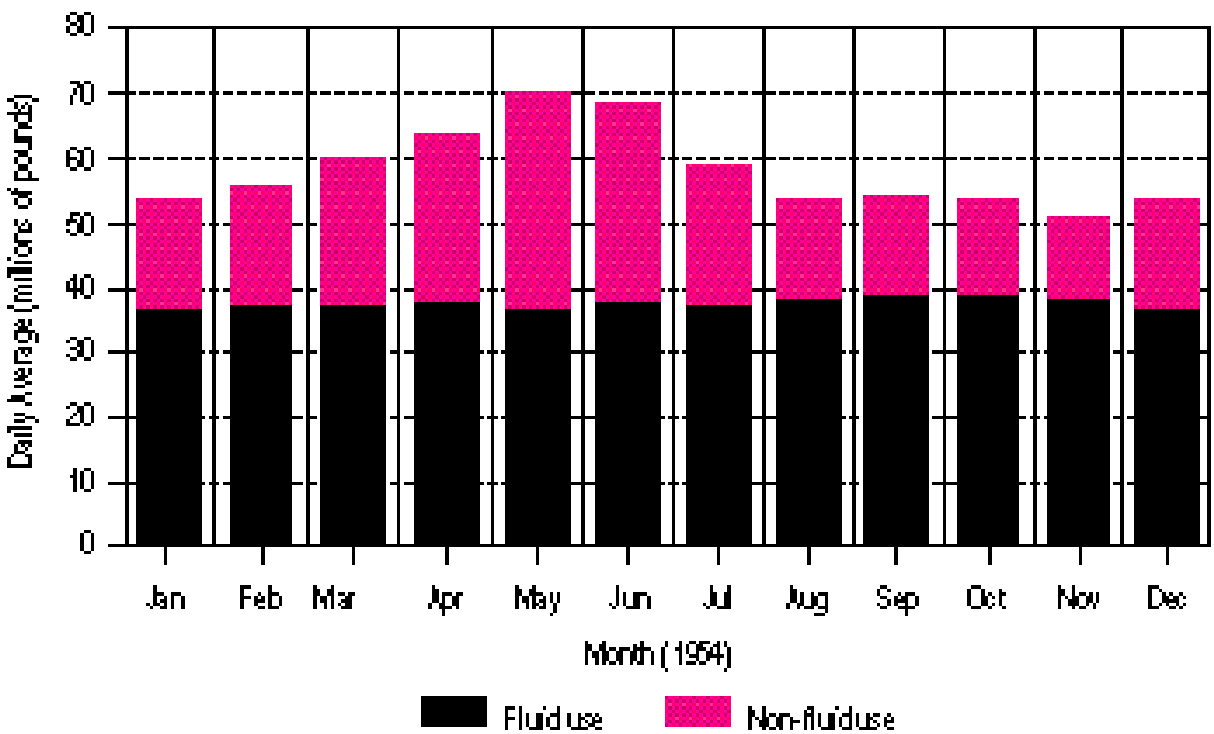


Table 5.8. Household consumption of fresh fluid milk in 1955 (mL d^{-1}).

Urbanization	Per Capita Consumption Rates[a]			
	United States		Northeast[c]	
	mL per day	Percent purchased at the store	mL per day	Percent purchased at the store
All	461	81	467	93
Urban	450	100[b]	478	100[b]
Rural Non-Farm	400	88	449	94
Rural Farm	585	16	599	2

[a] Sources: USDA (1955)

[b] It is assumed that all the milk in urban areas is purchased.

[c] Northeastern states included in the survey: Maine, New Hampshire, Vermont, Massachussetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.

Table 5.9. Per capita milk consumption rates for the population of the contiguous U.S., according to age and sex, $CR_{pc}(US,k)$. Derived from Tables 5.1 and 5.5 for 1954.

Age group index, k	Age		Population fraction, FPOP(k)	Per capita consumption rate, $CR_{pc}(k)$, in mL d^{-1}
	Year	Month		
5		0-2	0.0055	120
6		3-5	0.0055	420
7		6-8	0.0055	640
8		9-11	0.0055	640
9	1-4		0.088	520
10	5-9		0.095	700
11	10-14		0.083	680
12	15-19		0.072	640
13	Adult male		0.31	260
14	Adult female		0.33	170

More detailed information on factors discussed above that influence the milk consumption rates can be found in USDA (1955), PHS (1963a, 1963b), Spencer and Parker (1961), Thompson (1966), and Yang and Nelson (1986).

5.4.4. Per Capita Milk Consumption Rates Adopted in this Report for the Purpose of the Dose Assessment

For the purpose of the dose assessment, some of the milk consumption rates presented in *Table 5.5* have been averaged in the following manner:

- for the first year of life, four age groups are considered: infants aged 0-2 months, 3-5 months, 6-8 months, and 9-11 months;

- between 1 and 20 years, the age grouping remains the same as in *Table 5.5,* but the data were averaged over the male and female populations;

- age groups over 19 years were combined to form two adult categories (male and female).

The resulting per capita milk consumption rates for the populations in each age class in the contiguous U.S. are presented in *Table 5.9,* along with the population breakdown in each age group.

As shown in *Table 5.1,* the per capita milk consumption rates, $CR_{pc}(s)$, varied from state to state. It is assumed in this report that the milk consumption of (0-1)-y old infants was constant throughout the country, but that the milk consumption of all other age groups was related to the per capita milk consumption in the state:

$$CR_{pc}(s) = \sum_{k=5}^{k=8} (CR_{pc}(US,k) \times FPOP(k)) + \sum_{k=9}^{k=14} (CR_{pc}(s,k) \times FPOP(k)) \tag{5.9}$$

where:

k is the age and sex class index, and

FPOP(k) is the fraction of population in group k.

It is assumed that all age groups, with the exception of (0-1)-y old infants, drank milk in amounts proportional to the per capita milk consumption for the corresponding U.S. population:

$$CR_{pc}(s,k) = CK(s) \times CR_{pc}(US,k) \quad \text{for } k = 9 \text{ to } 14 \tag{5.10}$$

where

CK(s) is the coefficient of proportionality for state, s, which is assumed to depend only on the per capita milk consumption rate of the population in the state, so that *equation 5.9* can be written:

$$CR_{pc}(s) = \sum_{k=5}^{k=8} (CR_{pc}(US,k) \times FPOP(k)) + CK(s) \times \sum_{k=9}^{k=14} (CR_{pc}(US,k) \times FPOP(k)) \tag{5.11}$$

The coefficient of proportionality for each state, CK(s), is derived from *equation 5.11,* using the values of $CR_{pc}(s)$ given in *Table 5.1* and the values of $CR_{pc}(US,k)$ and of FPOP(k) given in *Table 5.9.* The per capita milk consumption in each age group (with the exception of (0-1)-y old infants) for each state, $CR_{pc}(s,k)$, are in turn derived from *equation 5.10*. The results are presented in *Table 5.10*.

Doses to the fetus are calculated assuming that the milk consumption rate of the mother is 800 mL d^{-1} for any area of the country. This consumption rate, which is high, the 95th percentile of the distribution, for an adult female, takes into account the increase of milk consumption by the expectant mother during the last stage of pregnancy. The same milk consumption rate is assumed to apply to the lactating mother.

Table 5.10. Per capita milk consumption rates for the year 1954 and the distribution of the population in each state, according to age and sex, $CR_{pc}(s,k)$, in mL d^{-1}. The per capita milk consumption rates for the (0-1)-y old infants are given in Table 5.9.

State	Age (years)				Adult Male	Adult Female
	1–4	5–9	10–14	15–19		
Alabama	359	486	475	443	180	121
Arizona	423	573	560	523	212	143
Arkansas	467	633	618	577	234	157
California	540	732	714	667	271	182
Colorado	423	573	560	523	212	143
Connecticut	635	860	840	784	319	214
Delaware	511	692	676	631	257	172
Washington D.C.	518	702	685	640	260	175
Florida	303	411	401	375	152	102
Georgia	335	455	444	414	168	113
Idaho	605	821	801	748	304	204
Illinois	613	831	811	757	308	207
Indiana	613	831	811	757	308	207
Iowa	613	831	811	757	308	207
Kansas	496	672	656	613	249	167
Kentucky	505	684	668	624	254	170
Louisiana	359	486	475	443	180	121
Maine	635	860	840	784	319	214
Maryland	511	692	676	631	257	172
Massachusetts	635	860	840	784	319	214
Michigan	613	831	811	757	308	207
Minnesota	642	870	850	793	323	217
Mississippi	467	633	618	577	234	157
Missouri	467	633	618	577	234	157
Montana	715	969	946	883	359	241
Nebraska	569	771	753	703	286	192
Nevada	426	577	564	526	214	144
New Hampshire	635	860	840	784	319	214
New Jersey	511	692	676	631	257	172
New Mexico	423	573	560	523	212	143
New York	635	860	840	784	319	214
North Carolina	386	524	511	478	194	130
North Dakota	715	969	946	883	359	241
Ohio	582	789	770	719	292	196
Oklahoma	467	633	618	577	234	157
Oregon	518	702	685	640	260	175
Pennsylvania	540	732	714	667	271	182
Rhode Island	635	860	840	784	319	214
South Carolina	386	524	511	478	194	130
South Dakota	715	969	946	883	359	241
Tennessee	467	633	618	577	234	157
Texas	408	553	540	505	205	138
Utah	423	573	560	523	212	143
Vermont	635	860	840	784	319	214
Virginia	443	601	587	548	223	149
Washington	569	771	753	703	286	192
West Virginia	386	524	511	478	194	130
Wisconsin	613	831	811	757	308	207
Wyoming	608	825	805	752	306	205

5.5. SUMMARY

- The production and utilization of cows' milk have been estimated for each county of the contiguous U.S. and for the year 1954 from Census data combined with the use of simple models.

- Milk for fluid use has been divided into four categories corresponding to the following population groups:

  category 1: those living on the farms in the county where the milk is produced,

  category 2: those living in the county where the milk is produced but not on farms;

  category 3: those living in a group of neighboring counties within a designated "milk region";

  category 4: those living at greater distances, that is in other "milk regions" in the same or another state.

- About 430 "milk regions" within the contiguous United States have been defined for this study. The flow of milk within the "milk regions", and from one "milk region" to another has been estimated on the basis of data from the U.S. Department of Agriculture.

- Delay times between production and consumption of milk of 1, 2, 3, and 4 days have been estimated for milk in categories 1, 2, 3, and 4, respectively.

- Per capita rates of milk consumption in the U.S. in the 1950s have been estimated as a function of age for eight classes of people under 20 years of age, and as a function of sex for adults. Per capita rates of milk consumption for each of the age groups in each of the 48 contiguous states also have been estimated.

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