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Behavior and food consumption pattern of the population exposed in 1949–1962 to fallout from Semipalatinsk nuclear test site in Kazakhstan

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Abstract

The relationship between radiation exposure from nuclear weapons testing fallout and thyroid disease in a group of 2,994 subjects has been the subject of study by the U.S. National Cancer Institute. In that study, radiation doses to the thyroid were estimated for residents of villages in Kazakhstan possibly exposed to deposition of radioactive fallout from nuclear testing conducted by the Soviet Union at the Semipalatinsk Nuclear Test Site in Kazakhstan between 1949 and 1962. The study subjects included individuals of both Kazakh and Russian origin who were exposed during childhood and adolescence. An initial dose reconstruction used for the risk analysis of Land et al. (2008) was based on individual information collected from basic questionnaires administered to the study population in 1998. However, because data on several key questions for accurately estimating doses was not obtained from the 1998 questionnaires it was decided to conduct a second data collection campaign in 2007. Due to the many years elapsed since exposure, a well developed strategy was necessary to encourage accurate memory recall. In our recent study, a focus group interview data collection methodology was used to collect historical behavioral and food consumption data. The data collection in 2007 involved interviews conducted within four eight-person focus groups (three groups of women and one group of men) in each of four exposed villages where thyroid disease screening was conducted in 1998. Population-based data on relevant childhood behaviors, including time spent in- and outdoors and consumption rates of milk and other dairy products were collected from women's groups. The data were collected for five age groups of children and adolescents ranging from less than 1 year of age to 21 years of age. Dairy products considered included fresh milk and other products from cows, goats, mares, and sheep. Men's focus group interviews pertained to construction materials of houses and schools, and animal grazing patterns and feeding practices. The response data collected are useful for improving estimates of thyroid radiation dose estimates for the subjects of an ongoing epidemiological study.

Introduction

From 1949 through 1962, the Soviet Union conducted 116 atmospheric nuclear weapons tests at the Semipalatinsk Nuclear Test Site (SNTS) in northeastern Kazakhstan (UNSCEAR, 2000). To determine prevalence of thyroid nodules and other related diseases in Kazakhstan in relation to fallout radiation exposures, the U.S. National Cancer Institute (NCI) in collaboration with the Semipalatinsk State Medical Academy (SSMA) and the Kazakh Research Institute for Radiation and Medical Ecology (IRME) conducted in 1998 a field study to collect information on 2,994 subjects of both Kazakh and Russian origin who were exposed in childhood and adolescence (aged less than 21 y) to radioactive fallout from nuclear weapons tests (Land et al 2008). In addition to the collection of historical data on the study subjects, thyroid screening was conducted in 1998 to obtain present-day disease prevalence (Land et al. 2008). The majority of the study subjects resided at the time of the testing in eight villages where substantial radioactive fallout occurred following six nuclear tests conducted on 29 August 1949 (test #1), 24 September 1951 (test #2), 12 August 1953 (test #4, thermonuclear device), 5 October 1954 (test #13), 29 July 1955 (test #19), and 7 August 1962 (test #148) (Gordeev et al 2002).

Radiation doses were received by the thyroid glands of residents of study villages primarily from two modes of exposure: (1) external irradiation from radionuclides deposited on the ground, and (2) internal irradiation primarily due to an intake of radioiodines (mainly, ^{131}I)

in milk and milk products from dairy animals grazing on pastures contaminated by nuclear weapons testing fallout. In general, reconstruction of individual doses requires detailed knowledge of both the radiation field, which is usually generalized to study subjects local to an area, and individual behaviors that affect both external and internal exposures. Behavioral parameters necessary for reconstruction of external and internal doses to the thyroid can be divided into the following categories in a decreasing order of importance: (1) temporary evacuation from the place of residence to avoid fallout exposure, (2) milk and milk product consumption rates and patterns, (3) daily time spent in- and outdoors, (4) shielding properties of construction materials of residences and schools, and (5) agricultural practices.

Deterministic estimates of radiation doses to the study subjects were performed in 2003 based on fallout exposure models known as the “joint U.S./Russian methodology” (Gordeev et al. 2006a, 2006b; Simon et al. 2006). Dose estimates suggested that village residents received high radiation doses from internal and external exposure of the thyroid gland; the individual doses among the study subjects were estimated as high as 0.65 Gy from external radiation and as high as 9.6 Gy from internal exposure (Land et al 2008). Dose estimates were based on behavioral and consumption-related data collected from (1) questionnaires administered to the study subjects during the 1998 field study, and (2) Russian and Kazakh data sources provided by the regional collaborators. However, some important exposure-related information was never collected or obtained. While data on exposure rates resulting from fallout in different villages and shielding properties of buildings were available, only minimal information was available for assessing the degree of contamination of dairy products (e.g., location of pastures, pasture grass consumption) and estimating individual exposure levels that are dependent on behavioral patterns (e.g. dietary intake rates, time spent indoors, construction material of houses).

The questionnaires administered in 1998 primarily included information about the frequency (daily, weekly, never) of consumption of cow milk, goat milk, cottage cheese, sour milk and sour cream at the time of each important nuclear test assuming that individual consumption rates could be derived from simple information already available on typical serving sizes. During the 1998 field study, however, it was also recognized that some food products were seasonal and ethnic-group specific, and that consumption rates could vary substantially among individuals. This recognition resulted in the development and administration of a supplemental questionnaire in two of the eight study villages, to inquire about the previously unrecognized use of milk from a variety of types of dairy animals other than cows including mares (horses), sheep, and possibly camels. The 1998 questionnaires had two other limitations. First, they did not inquire about the amount of time each child spent indoors daily. Secondly, some subjects were too young (aged less than 10 y) at the time of exposure to be able to reliably recall quantitative information about their milk consumption habits.

Because of the long time elapsed since the nuclear tests were conducted (five to six decades), an improved strategy was deemed necessary to overcome normal memory recall limitations. The focus-group and key-informant interview strategy was chosen as a means to stimulate memory recall and to collect new data needed to improve thyroid dose estimates. In 2007, we conducted a focus-group and key-informant interview study in Kazakhstan in villages included in the 1998 study. The purposes of the present paper are to briefly describe the data collection by these methods and to provide the central estimates of the most important major parameters used in most environmental thyroid dose reconstruction models.

Materials and methods

Focus groups

The focus group interview is a technique that has been successfully used to collect historical data about dietary patterns (McLafferty 2004). Focus groups have the advantage of being able to stimulate recall from discussions about the time period in general with a focus on lifestyle questions of interest. Participant interaction is a unique and compelling feature of focus groups where participants share their experiences to describe the range of experiences in a group as well as the reasons for differences among participants (Kitzinger 1995).

The focus groups field study was conducted in August–September 2007 in four of the eight villages screened in the 1998 field study. Two villages are predominantly Kazakh (Kaynar and Karaul) in ethnic origin, and two are primarily Russian (Dolon and Kanonerka) (Fig. 1). Those villages represent a range from moderate to high fallout exposure levels (Gordeev et al. 2002). Characteristics of focus-group interview participants are given in Table 1. In each village, three focus groups (except Dolon) with up to eight women (mothers and caregivers of children living in the villages at the time of the nuclear tests) and one focus group of eight men were interviewed. Only two women's focus groups were interviewed in Dolon, due to the limited population size. In Karaul and Kaynar, where the populations are nearly 100% Kazakh, the three women's groups were all Kazakh. In Kanonerka, all three women's groups were Russians while in Dolon, one women's group was Kazakh and one was Russian. In total, 11 women's focus group (seven Kazakh and four Russian) and four men's focus groups were interviewed involving 113 persons (82 women and 31 men).

In a single village, the men's group included both Russians and Kazakhs because fewer elderly men were available and farming practices were less likely to vary by ethnicity within any given village. Ages of the 54 Kazakh and 28 Russian women who participated in focus groups ranged from 65 to 96 y, with a median age of 75 y. Ages of the 17 Kazakh and 14 Russian men who participated in focus groups ranged from 68 to 90 y, with a median age is 73 y.

The focus group participants were selected from residents who were living in the fallout-affected villages selected for the 1998 field study. Since many of the individuals in the 1998 study were too young at the time of exposure to know or remember their milk consumption habit, mothers and caretakers of children in the affected villages were considered a more reliable surrogate source of those data. Furthermore, given that many study subjects' mothers were no longer alive, women whose children were less than 21 y of age during the exposure years (1949–1962) were also asked to participate in focus groups, to provide information about children's dietary practices.

The women's groups provided information about the average length of time children spent in- and outdoors daily (i.e., when at home and when in school). As all of the major nuclear tests were conducted during late July through early October, participants of the study were asked to provide data related to August–November for the entire period of time from 1949 through 1962, i.e., for the general period of the 1950s. The women's groups also provided information about children's milk and dairy product consumption patterns. As mothers had less precise knowledge of what their children ate during adolescent ages than during infancy, 35 women (aged less than 72 y at the time of the interview) were asked about their own consumption habits at age 15–21 y as surrogate data. Data obtained for age 15–21 y from the mothers were combined with data reported for the children of the same age group. According to our collaborators in Kazakhstan and village residents, the diet remained constant between 1949 (and even 10 or 15 years earlier) and 1962; newer foods were not introduced into the village diets until the 1960s and later. For these reasons, dietary

information collected in the focus group interviews is thought to appropriately reflect the situation during the years of exposures. In order to try and capture the inter-individual variability of behavior patterns, multiple groups per village were interviewed. Because the types of information collected from the men's groups pertain only to village-level practices, only one men's group per village was interviewed.

The topics for discussion in the women's and men's focus groups were intended to reflect the social practices of the villages at the time of the nuclear tests. Women mainly took care of children and, therefore, were considered to be a reliable source of information on diet and activity patterns of children. Men were primarily responsible for the care of dairy animals (pasturing and supplemental feed of dairy animals, etc.) and were considered to be able to provide detailed information on agricultural practices at this time. Information on construction materials of houses and schools, and the evacuation of villages and dairy animals in 1953 prior to thermonuclear test was also obtained from men's focus groups.

Focus group interviews were conducted by four faculty members of the SSMA who received one week of specific training at RTI International (Bethesda, MD, USA). One moderator was a native Russian speaker and the other three were native bilingual Russian/Kazakh speakers. To stimulate participant memory, the focus group moderators used detailed probes in the form of open-ended questions for each topic described above. Answers of the participants were captured during the focus group sessions on data collection sheets designed to elicit the information. Detailed description of how focus group interviews were conducted in this study can be found elsewhere (Schwerin et al., 2010).

Key informant interviews

In addition to consumption and behavioral data which varies either by individual or age group within each ethnicity, data about factors that were fairly constant across individuals (e.g. agricultural practices, preparation times for milk products) are also required for environmental dose reconstruction. To collect that information, individual interviews were conducted with "key informants", i.e., persons with extensive experience and who could recall different aspects of daily life in the study area at the period of atmospheric nuclear weapons testing. Thirty-three "key informants" were interviewed in 2007 in the eight villages of the 1998 study: the four villages where focus groups were interviewed plus Sarzhal, Korostely, Novopokrovka, and Bolshaya Vladimirovka (Fig. 1). Sarzhal is a village of predominantly Kazakh ethnicity while Korostely, Novopokrovka and Bolshaya Vladimirovka are villages of primarily Russian ethnicity. In each village, four key informants were interviewed, except Kanonerka where five persons were interviewed (Table 1). Ages of 15 female and 18 male key informants ranged from 68 to 84 y, with a median age of 77 y. In the 1950s, these individuals worked in the villages as agricultural specialists (n=9), teachers (n=7), Soviet authorities (n=4), cowboys (n=4), drivers (n=4), veterinary doctors (n=2), medical doctor (n=1), and other specialists (n=2).

The key informants were requested to provide information on lifestyle and agricultural practices during 1949–1962, including: (1) consumption of milk and milk products by women during pregnancy; (2) availability of leafy vegetables for consumption by children; (3) the fraction of the families (by ethnicity) that lived in either wooden and adobe houses; (4) methods and times of preparation of milk products such as fermented mare milk (koumiss), cottage cheese, and sour milk; (5) attendance of boarding and day schools by children, and construction materials of schools; (6) locations of pastures relative to the village and dairy animal feeding practices; and (7) evacuations near to the time of the 1953 test of a thermonuclear device (relevant only to Karaul, Sarzhal, and Kainar). The responses of key informants from the interviews were also recorded on paper forms.

Information collected by focus group and key informant interviews

Table 2 describes types of information collected by focus group and key informant interviews. Two types of data were derived from the women's focus groups interviews: first, group consensus data, including, but not limited to (a) types of milk available for children, (b) time children spent in- and outdoors daily, and second, individual data on the frequency and amounts of different types of milk and milk products consumed by children and by women during breast feeding. Group consensus data were used to estimate group-specific parameters (e.g., by ethnicity and village) while individual food consumption data were used to determine inter-individual variability between children as well as between women during pregnancy and breastfeeding. In contrast, key informants provided responses that reflected their individual expert opinion. Individual responses from key informants (except consumption rates for women during pregnancy) were used for evaluating the variability in parameters between ethnicity groups and between villages. Some specific pieces of information were collected from both consensus groups and from key informants (Table 2) with the goal of better understanding average behaviors and conditions as well as inter-individual variability.

All numerical information accrued from the focus group participants and provided by key informants was synthesized into tables and databases. The characteristics of various groups in terms of demography, milk and milk-product consumption, time spent indoors, etc., are presented by basic descriptive statistics, such as frequency distribution, median, and arithmetic mean with standard error. The central estimates of behaviour and food consumption parameters are discussed in sections below.

Results

Parameters of external exposure

Time spent in- and outdoors—The average amount of time children spent in- and outdoors daily was reported by women's focus groups for two seasons of the year: summer, specifically the month of August when school was not in session, and autumn, specifically September–November, when school was in session. Time spent at school was also reported for the period of the year when school was in session. Knowledge of time spent at school was important for Russian villages, as construction materials of residential homes could be different from the construction materials of schools where the subjects attended for months at a time (see sections "Construction material of houses" and "Construction material of schools").

Table 3 shows average times per day spent in- and outdoors, by season, ethnicity, and age. For pre-school children (aged 0–6 y), the time spent indoors daily was remarkably similar between August, when school was not in session, and September–November, when school was in session. However, for school children aged 7–14 y, there were significant differences: 14 h per day in August compared to 19.5 h in September–November in Kazakh villages, and 13.5 h per day in August compared to 18.5 h in September–November in Russian villages. The time spent in school was similar for children in Kazakh and Russian villages: 4.5 h and 6.5 h for age groups 7–14 y and 15–21 y, respectively. It should be noted that time spent in school is given for age up to 18 y when children graduated from the high school.

According to the women's focus group interviews, boys older than 7 years of age spent more times outdoors helping their fathers with the dairy animals while girls spent more time indoors helping their mothers with household chores. On average, there was about one hour

difference in time spent indoors between boys and girls (not shown in Table 3); however, there was no ethnic difference indicated.

Construction material of houses—One consensus-type question sought from the men's focus groups was about the fraction of Kazakh and the fraction of Russian families who resided in wooden (adobe) houses in the 1950s. Key informants were also asked the same questions. Table 4 summarizes the ethnicity- and village-specific fractions of families that lived either in wooden or adobe houses for five villages of predominant Russian ethnicity. In contrast, those villages of predominantly Kazakh ethnicity had only adobe homes available, since wood construction materials were not available. This unusual instance where the fraction represented 100% is not provided in Table 4.

As can be seen from Table 4, in all Russian villages except Novopokrovka, about one-half (range of 0.4 to 0.6) or almost all (range of 0.9 to 1.0) Russian families resided in wooden houses in the 1950s. The fraction of Kazakh families that resided in wooden houses varied from "almost none" (range of 0 to 0.1) to "almost all" (range of 0.9 to 1.0). In Novopokrovka, adobe was the main construction material and less than one-half of the families of both Kazakh and Russian ethnicity resided in wooden houses. Kazakhs tended to live in adobe houses even in villages with predominant Russian ethnicity where, as a rule, wood was available as a construction material. As can be seen from Table 4, although almost all Russians resided in wooden houses in Dolon, less than half of Kazakh families had wooden houses.

Construction material of schools—Village-specific information on construction material of schools was collected from the men's focus groups and from key informants. The obtained data indicate that wood was used to construct schools in the 1950s in Russian villages, except Korostely where there was a brick school at that time. As mentioned above, in villages of predominantly Kazakh ethnicity only adobe was used as a construction material regardless if the building was a home or school.

Evacuation for the 1953 thermonuclear test—Residents of three villages (Karaul, Kaynar and Sarzhal) were evacuated prior to the thermonuclear test of 12 August 1953. According to men's focus group and key informants interviews, residents and their dairy animals were evacuated as late as three days before the test and not allowed to return for a period from seven days to up to one month after the test. Residents of Karaul were evacuated to the villages of Sergiopol and Bakanas located 140 km to the south-east and south, respectively. Residents of Sarzhal were evacuated to Ayaguz and Bakanas located 230 km to the south-east and south, respectively, and to the village of Znamenka located 80 km to the north-east. Kaynar residents were evacuated to Kikshetau (40 km to the west); Kusak (90 km to the west) and Egindybulak (100 km to the north-west). According to Russian monitoring data, no substantial fallout from the test was detected at any of the locations where village residents were moved to, except Sergiopol and Ayaguz, where a low, but significant amount of fallout was detected[a]. Therefore, temporary residence at those two locations during the evacuation was taken into account in the dose reconstruction for evacuated study members.

Parameters of internal exposure

Consumption of dairy products by children—Participants of women's focus groups were asked how much and how often their children consumed fresh milk from cows, goats, mares and sheep; and dairy products: koumiss (fermented mare milk), sour milk, cottage

[a]H.L. Beck, personal communication. Rockville, MD; January 2008.

cheese, and sour cream (only in village Kanonerka) in the 1950s. At the beginning of the 2007 field study in Karaul, we recognized that the local food habits of drinking cow milk with tea might also be an important source of ^{131}I intake. Therefore, focus group interviews in three villages (Kainar, Dolon and Kanonerka) visited after Karaul included discussion and questions about consumption of cow milk with tea. Participants in women's focus groups reported consumption rates for 264 children, including 190 Kazakhs (101 females and 89 males) and 74 Russians (34 females and 40 males). Figure 2 presents the distribution of the children for whom behavior and consumption data were reported by women's focus by year of birth and by gender.

Table 5 presents ethnicity- and age-specific fractions of children who consumed different types of animal milk and milk products as derived from the focus group interview data. At all ages, a majority of the children consumed cow milk, up to 91% of Kazakhs and up to 90% of Russians, or cow milk with tea, up to 92% of Kazakhs and up to 67% of Russians (with the exception of infants). Ethnic differences are also seen in the data of Table 5. In contrast to Russians, Kazakhs reported consumption of goat and sheep milk, as well as fresh and fermented mare milk (koumiss). Among Russians, there was no indication that milk from goats, sheep or mares was consumed. In contrast, consumption of goat, sheep and mare milk was reported for a small fraction of Kazakh children (up to 9%). The fraction of Kazakh children who consumed sour milk tended to be larger than that of Russian children, while the fraction of consumers of cottage cheese among Russian children tended to be larger than that among Kazakh children. According to the data obtained from the women's focus group interviews, there was no difference indicated in milk and milk-product consumption pattern between boys and girls of the same ethnicity and age. Although the 1998 field study indicated consumption of camel milk, no consumption of this type of milk by children was reported in present study.

The average ethnic- and age-specific consumption rate of milk and milk products as derived from focus group interviews are presented in Table 6. The data indicate that fresh cow milk and sour milk were the primary dairy products consumed by both Kazakh and Russian children in the 1950s. Significant ethnic differences are seen for the daily consumption rates for each dairy product. Russian children at all ages consumed larger amounts of cow milk while Kazakhs consumed more sour milk than did Russian children. Koumiss consumption increased with age among Kazakhs while Russians reported they did not consume koumiss but more cow milk with tea than did Kazakhs. Although consumption of fresh milk from goats, sheep and mares was reported for Kazakh children, estimated consumption rates are based on very few responses. While the fraction for cottage cheese consumption among Russian children was larger than that among Kazakhs, higher daily consumption rates for cottage cheese were seen for Kazakh children

Consumption of dairy products by women during pregnancy and breastfeeding—Ethnic-specific food consumption patterns for women during pregnancy (reported by 22 key informants) and during breastfeeding (reported by 82 participants of women's focus groups) are presented in Table 7. Fresh cow milk was the main dairy product consumed by women during pregnancy: 85% Kazakh women and 100% Russian women. According to the key informant interviews, a significant fraction of Kazakh women also consumed koumiss (85%) and fresh mare milk (69%) during pregnancy.

As can be seen from Table 7, cow milk was also the main dairy product for women during breastfeeding. Although consumption of cow milk itself was reported for 21% Kazakh women and for 48% Russian women, almost all women of both ethnicities consumed cow milk with tea, 96% and 92% of Kazakhs and Russians, respectively. Almost half of Kazakh women consumed koumiss during breastfeeding.

As mentioned, there was no tradition among Russians to consume milk or milk products from goats, sheep or mares. For this reason, the same ethnic specific preferences reported for Russian children were reported for Russian child-bearing women. In contrast with Russians, however, Kazakh women reported consumption of goat, sheep, and mare milk as well as koumiss. The consumption of sheep and mare milk was reported for 25% and 69%, respectively, of pregnant women, while a small fraction (2 to 8%) of women consumed those dairy products during breastfeeding (Table 7).

Breastfeeding—Ethnic-specific behaviors with respect to breastfeeding are presented in Table 8. According to women's focus group interviews, nearly all Kazakh and Russian women breast fed their children (96% and 100%, respectively). The duration of breastfeeding in this population in the 1950s, as derived from the interviews, averaged 18 months and 15 months among Kazakh and Russian women, respectively. Other foods besides breast milk (e.g. cow milk, bread, porridge) were introduced to infants (age less than 1 y), on average, at age 6 months for 34% Kazakh and at age 8 months for 71% of Russian infants.

Preparation of milk products—Milk products, such as koumiss, sour milk, and cottage cheese are prepared from fresh milk. Hence, there was a time delay between the milking of dairy animals and the consumption of milk products. That time interval is, of course, important to dose reconstruction as it determines the amount of decay of radionuclides, in particular, the radioiodine concentrations in prepared milk products. The key informant interviews provided data on local practices for preparing milk products. Ethnic-specific data on time required for preparation of milk products, as well as the quantity of these products produced from 1 L of fresh milk, are presented in Table 9.

Leafy vegetable consumption by children—According to key informant interviews, leafy vegetables were not consumed in the 1950s in Kazakh villages as there was no tradition to grow or consume such vegetables. In contrast, in Russian villages, children (aged more than 4 y) consumed certain leafy vegetables, primary wild sorrel during the season when it grew, usually May–June, or sometimes as last as July. In later months of the year, wild sorrel was not available due to typically dry weather conditions in Kazakhstan. As only the period of August through November was considered for the dose reconstruction in the present study, no other information on leafy vegetables consumption was collected.

Agricultural practices—Table 10 presents information on agricultural practices in the 1950s in villages located close to SNTS, as reported by men's focus groups and key informant interviews. Although information was provided for goats, sheep and mares, no milking of these animals was reported in Russian villages. As less supplemental feed was available for dairy animals in Kazakh villages than in predominantly Russian villages, the pasture period was longer in Kazakh villages than in Russian villages (through 1 December compared to 15 November). As can be seen from Table 10, pastures were located, on average, further from Kazakh villages in comparison with Russian villages, and dairy animals in Kazakh villages consumed less grass than animals in Russian villages. We believe that the difference in grass consumption primarily reflects less availability of grass in the southern Kazakh areas. Mares used for milk production in Kazakh villages were pastured inside or very close to each village since mares should be milked frequently, sometimes every hour. According to pasture practice in Kazakh villages, in the middle of September mares (horses) were moved to the distant pastures 30–100 km away from the village, implying that fresh mare milk was not available for village residents after that date.

Evacuation for the 1953 thermonuclear test—As mentioned, inhabitants from Karaul and Sarzhal were temporary evacuated to the settlements of Sergiopol and Ayaguz where smaller, but significant, amounts of fallout were detected. According to the focus group and key informant interviews, dairy animals from Karaul and Sarzhal were not evacuated to Sergiopol and Ayaguz (but to Bakanas and Znamenka) together with the people. In this case, the evacuees consumed contaminated milk and milk products derived from local dairy animals of the village to which they were evacuated. In the case of those two villages, the temporary location of study subjects is taken into account in the reconstruction of internal dose.

Discussion

Based on the focus groups and key informants, several assumptions used in a previous dose assessment (Land et al. 2008) have been modified. In particular, the interview data indicate significant differences in time spent indoors between Kazakh and Russian children for some age groups (Table 3). In addition, a difference in time spent indoors by school children between August (school was not in session) and September–November (school was in session) derived from the present interview data was not previously considered.

The previous assumption that home construction materials (affecting external dose estimation) is strictly a function of ethnicity was found not to be valid for predominantly Russian villages. In fact, we found that in Russian villages, both wood and adobe were used to construct houses, and that the fraction of Kazakh and Russian families that resided in wooden or adobe houses varied among the villages (Table 4).

Ethnic differences in diet are clearly seen from food consumption data collected in our study. While there was no tradition among Russians to consume milk or dairy products from goats, sheep and mares; Kazakhs were confirmed to have consumed goat and sheep milk as well as fresh and fermented mare milk (koumiss). Our study clearly shows that Russian and Kazakh children differed in their consumption patterns and amount of dairy products consumed but that there was no difference in the types of milk and milk products between boys and girls of the same ethnicity and age. Mare and sheep milk were found to be available only one to two months each year.

We compared the average age-dependent consumption rates of cow milk (including cow milk with tea), sour milk, cottage cheese, and koumiss obtained in our 2007 study with the values in the previous dose estimation (Fig. 3). Rates used in the earlier dose reconstruction had been reported by the Kazakhstan National Institute of Nutrition for Kazakh and Russian populations of the Beskaragay district during the years 1964–1968; though no information is available on how those rates were derived. Beskaragay district consist of around 25 villages, including the villages of Bolshaya Vladimirovka (administrative center of district), Dolon, and Kanonerka which are also included in the present study. As can be seen from Fig. 3, in general, the previous dose assessment assumed much lower consumption rates of cow milk compared to our 2007 study data, especially among Russian children. Consumption of sour milk by children of both ethnicities estimated in the present study was, as a rule, lower than that assumed in the previous dose reconstruction study. There was a good agreement between the two studies in the consumption rates of cottage cheese and koumiss for children aged 4–6 y and 7–14 y; though not for younger children.

The focus group and key informant interview methods are data collection strategies substantially different from individual subject interviews. The latter is not only extremely time-consuming but has relevance only when study individuals have a reliable recall of the subject of interest. Individual interviews generally do not benefit from group discussions,

which are the major strength of focus group interviews. Those discussions can serve to stimulate memory recall or in overcoming individual timidity or reluctance to provide information on an individual basis.

In the present study, focus group and key informant interviews were used to collect information on events of about 60 years ago from surviving village residents who have not migrated elsewhere. The occasional use of interviewees as surrogates to the study subjects is not viewed as a weakness because of the fact that, during the Soviet era, village life in Kazakhstan could be described as subsistence living conditions, which means an extremely limited variety in foods available in any given village and among village residents including actual study subjects and interviewed residents.

The limitations of the focus group interview method are well recognized, but pertain primarily to its lesser ability to capture data specific for individual dose estimation. This limitation is not absolute, however, as we have shown that biases in dosimetry assumptions based on poorly documented data sources can be reduced by focus group and key informant interview data. Moreover, sophisticated Monte Carlo sampling strategies in a stochastic dose assessment framework can utilize focus group data to account for shared and unshared uncertainties (see NCRP 2007 and 2010) among individuals, overcoming some of the disadvantages and possibly improving the precision of dose-response analyses. In the present case, there is the considerable advantage to combine and modify previous (1998) interview data with the findings from the 2007 focus group and key informant interviews. Detailed analysis of variability and uncertainty in behavior and food consumption parameters of dosimetry models derived from collected data and its implementation in stochastic calculations of radiation doses will be described in subsequent papers.

Conclusions

Focus group and key informant interviews were conducted to collect historical data on behavior and food consumption in a Kazakhstan population potentially exposed to radioactive fallout from nuclear weapons tests. We obtained demographic-group specific data on relevant childhood behaviors, including time spent in- and outdoors, and consumption rates of milk and other dairy products. New information was also collected on food consumption patterns for women during pregnancy and breastfeeding; on agricultural practices; on evacuations for the 1953 thermonuclear weapon test; and preparation of milk products. The earlier dose assessment effort used data based on general, less detailed assumptions about these important parameters. Information from the present study has the potential to improve the dose estimation for the subjects of the 1998 thyroid disease study by correcting biases from previous assumptions and by better assessment of certain parameters important to dose estimation.

The data presented here are the first detailed information on several key aspects of daily life in rural villages in Kazakhstan during the years of Soviet nuclear testing. The new information collected allows estimation of the uncertainties related to shared and unshared errors in our dosimetry model. Information obtained from the focus groups and key informants are being used to define the village-, ethnicity-, age-, and gender-specific (where appropriate) probability density distributions of important behavior and food consumption parameters for dosimetry models that are used to reconstruct external and internal doses. These data are being used to improve thyroid radiation dose estimates for an update of the risk analyses reported by Land et al. (2008).

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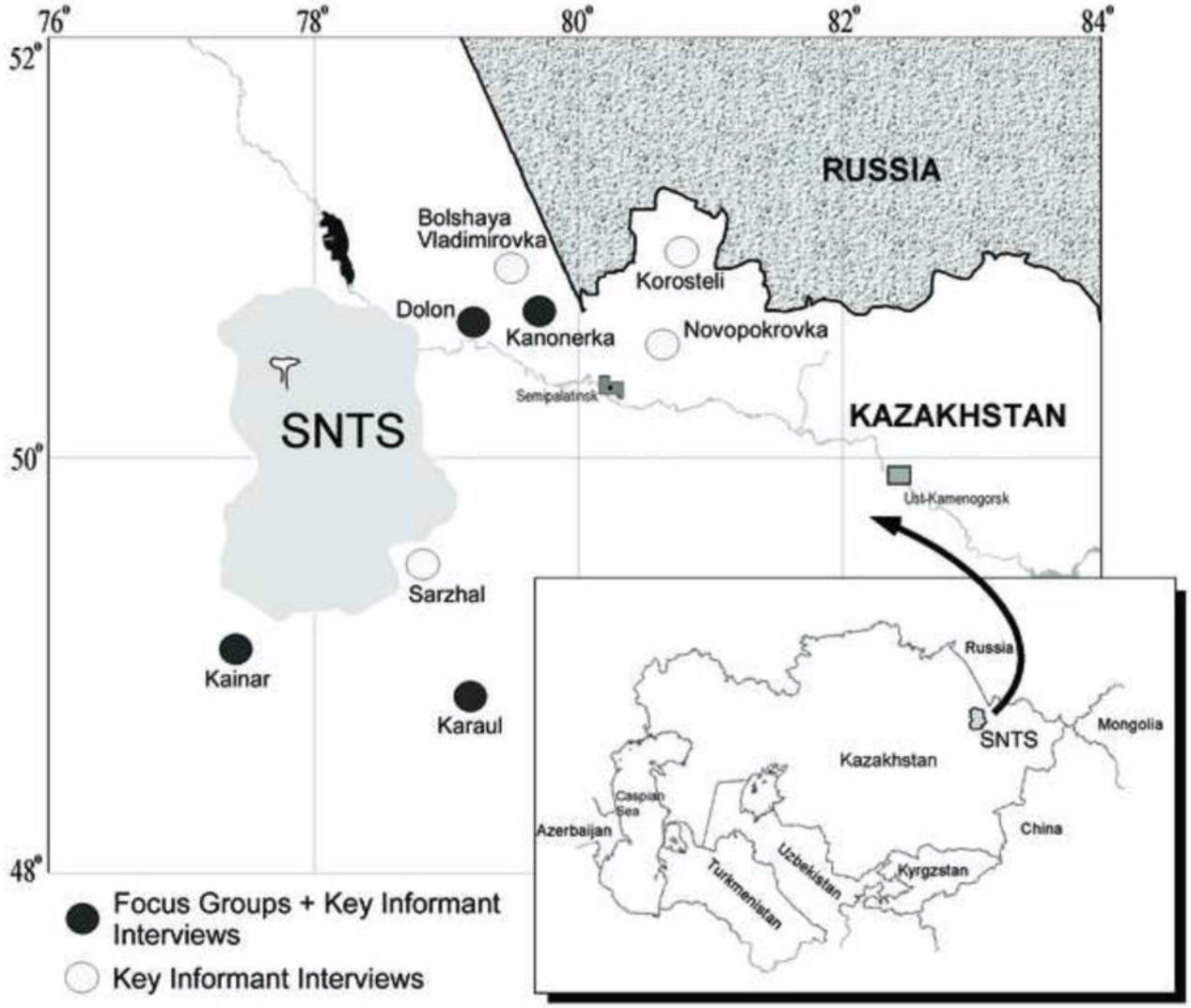

Fig. 1.
Locations selected for focus group interviews and key informant interviews. SNTS: Semipalatinsk Nuclear Test Site

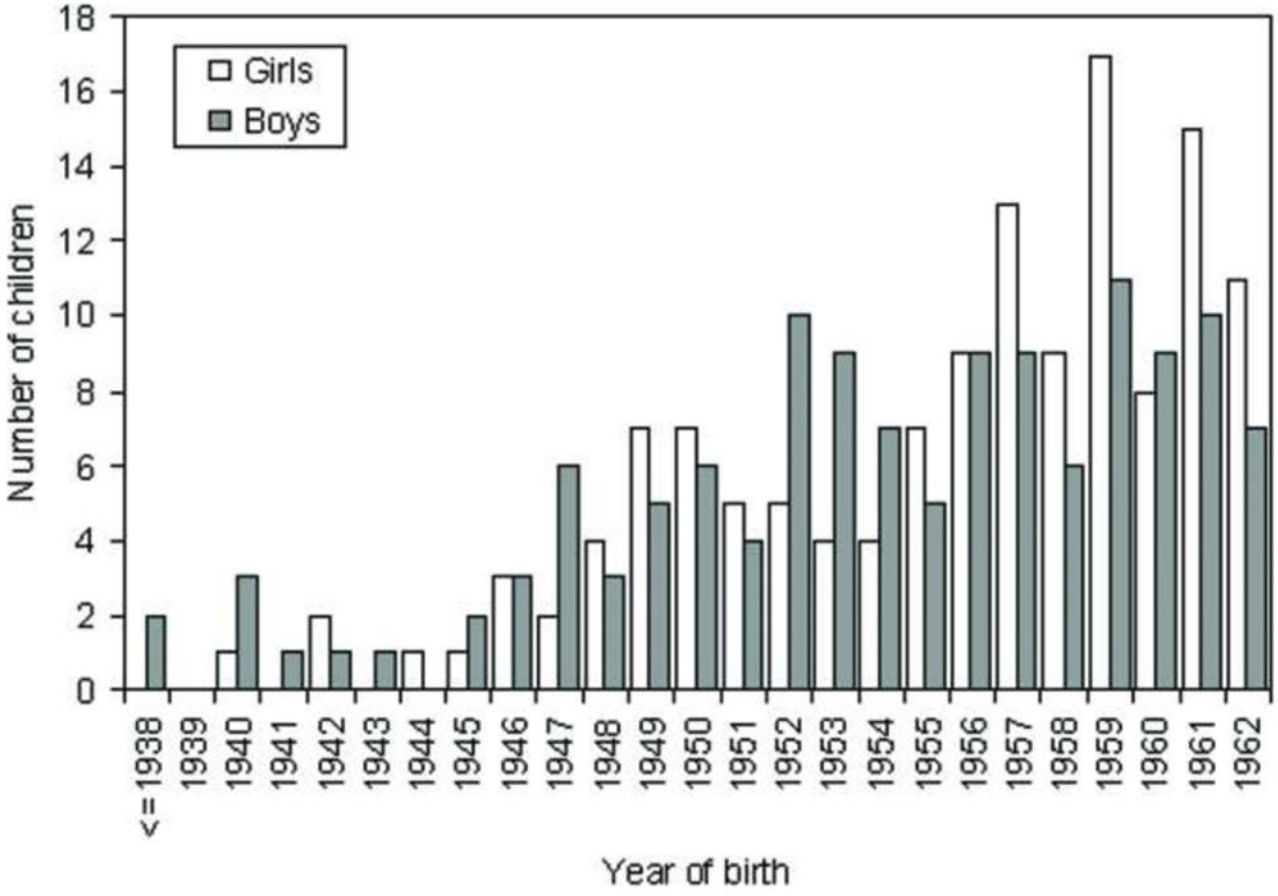

Fig. 2.
Distribution by the year of birth of the children for whom behavior and consumption data were reported by women's focus groups

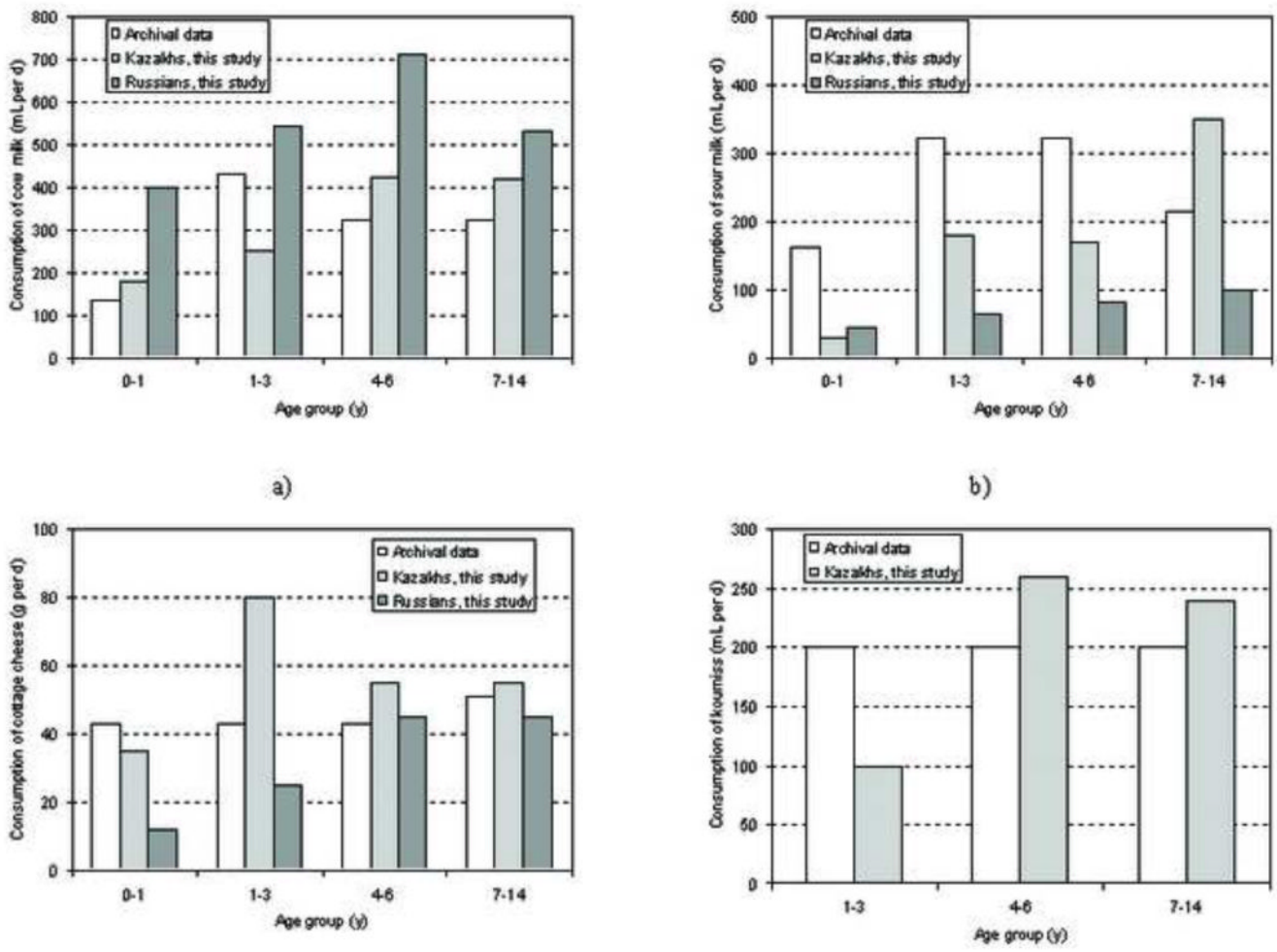

Fig. 3.

Comparison of age-dependent consumption rates of a) cow milk (including cow milk with tea), b) sour milk, c) cottage cheese, and d) koumiss. Archival data are from the Kazakhstan National Institute of Nutrition for Kazakh and Russian populations of the Beskaragay district during the years 1964–1968

Table 1

Characteristics of focus group and key informant interview participants.

Village	Predominant ethnicity	Women's focus group			Men's focus group			Key informants		
		Ethnicity	Number of participants	Average age (y)	Ethnicity	Number of participants	Average age (y)	Ethnicity	Number of participants	Average age (y)
Kaynar	Kazakh	Kazakh	8	76.6	Kazakh	8	76.6	Kazakh	4	75.0
		Kazakh	8	78.5	-	-	-	-	-	-
		Kazakh	8	75.1	-	-	-	-	-	-
Karaul	Kazakh	Kazakh	8	77.9	Kazakh	8	72.5	Kazakh	4	74.0
		Kazakh	8	70.5	-	-	-	-	-	-
		Kazakh	8	72.0	-	-	-	-	-	-
Dolon	Russian	Russian	6	70.8	KZ+RU[a]	7	74.9	KZ+RU	4	76.8
		Kazakh	8	74.9	-	-	-	-	-	-
Kanonerka	Russian	Russian	7	75.4	Russian	8	73.6	Russian	5	79.8
		Russian	7	75.4	-	-	-	-	-	-
		Russian	6	76.7	-	-	-	-	-	-
Sarzhal	Kazakh	-	-	-	-	-	-	Kazakh	4	73.5
Korostely	Russian	-	-	-	-	-	-	KZ+RU	4	74.8
Novopokrovka	Russian	-	-	-	-	-	-	KZ+RU	4	79.0
Bolshaya Vladimirovka	Russian	-	-	-	-	-	-	Russian	4	74.3

[a] Kazakh and Russian

Table 2

Type of information collected by focus groups and key informants.

Mode of exposure and type of information	Focus Group Interview		Key Informant Interviews
	Men	Women	
External dose			
Time spent indoors	-	Group consensus	-
Fraction of the families that lived in wooden/adobe houses	Group consensus	-	Expert opinion
Attendance of boarding and day schools by children	Group consensus	-	Expert opinion
Construction materials of schools	Group consensus	-	Expert opinion
Evacuation at time of 1953 thermonuclear test	Group consensus	-	Expert opinion
Internal dose			
Consumption of milk and milk products by children	-	Individual data	-
Consumption of milk and milk products by women during breast feeding	-	Individual data	-
Consumption of milk and milk products by women during pregnancy	-	-	Expert opinion
Availability and consumption of leafy vegetables by children	-	Individual data[a]	Expert opinion
Preparation of milk products	-	-	Expert opinion
Types of milk available to feed children	Group consensus	Group consensus	Expert opinion
Agricultural practices: Location of pastures, feeding of dairy animals, milk production	Group consensus	-	-
Agricultural practices: Consumption of pasture grass by dairy animals	-	-	Expert opinion

[a] One group in Dolon

Table 3

Estimates of time spent indoors daily (h) in August–November in the 1950s by age.

Season	Age, y	Average time spent indoors (h) per day[a]			
		Kazakh		Russian	
		Total	In school	Total	In school
School not in session (August)	<1	23.3	-	23.6	-
	1–3	19	-	15	-
	4–6	15.3	-	15	-
	7–14	14	-	13.5	-
	15–21	11	-	13	-
School in session (September–November)	<1	22.4	-	23.5	-
	1–3	19	-	15.5	-
	4–6	18.5	-	14.8	-
	7–14	19.5	4.5	18.5	4.5
	15–21	19	6.5[b]	20.8	6.5[b]

[a] Median of the range reported by focus groups

[b] For age up to 18 y

Table 4

Fraction (range) of the Kazakh and Russian families that lived in wooden/adobe houses in villages with predominant Russian ethnicity.

Village	Fraction of the families living in			
	Wooden houses		Adobe houses	
	Kazakh	Russian	Kazakh	Russian
Dolon	0.1–0.4	0.9–1.0	0.6–0.9	0–0.1
Kanonerka	0.7–0.8	0.9–1.0	0.2–0.3	0–0.1
Korostely	0–0.1	0.4–0.6	0.9–1.0	0.4–0.6
Novopokrovka	0.1–0.4	0.1–0.4	0.6–0.9	0.6–0.9
Bolshaya Vladimirovka	0.9–1.0	0.9–1.0	0–0.1	0–0.1

Table 5

Fraction of consumers (%) of milk and milk products among children of different ages.

Dairy product	Ethnicity	Age, y				
		<1	1–3	4–6	7–14	15–21
Cow milk	Kazakh	46	86	91	78	60
	Russian	60	90	81	80	65
Goat milk	Kazakh	7	5	6	0	0
	Russian	0	0	0	0	0
Sheep milk	Kazakh	8	3	4	9	2
	Russian	0	0	0	0	0
Mare milk	Kazakh	6	5	6	3	9
	Russian	0	0	0	0	0
Cow milk with tea	Kazakh	0	31	77	75	92
	Russian	0	31	33	55	67
Koumiss	Kazakh	0	9	24	43	73
	Russian	0	0	0	0	0
Sour milk	Kazakh	17	69	80	83	70
	Russian	14	35	33	26	50
Cottage cheese	Kazakh	5	29	46	57	50
	Russian	15	70	87	54	63
Sour cream	Russian[a]	6	38	65	68	91

[a]Only for village Kanonerka

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Table 6

Consumption rate[a,b] (mL d^{-1}) of milk and milk products in the 1950s.

Dairy product	Ethnicity	Age, y				
		<1	1–3	4–6	7–14	15–21
Cow milk	Kazakh	180±15	230±10	380±30	370±40	330±45
	Russian	400±40	430±35	610±55	450±65	*700± 220*
Goat milk	Kazakh	*125* [c]	-[d]	-	0	0
	Russian	0	0	0	0	0
Sheep milk	Kazakh	90±10	-	*250* [c]	-	-
	Russian	0	0	0	0	0
Mare milk	Kazakh	155±20	*300± 30*	*350± 50*	-	*800± 220*
	Russian	0	0	0	0	0
Cow milk with tea	Kazakh	0	*20* [c]	45±2	50±2	75±15
	Russian	0	115±15	100±25	80±7	*100± 10*
Koumiss	Kazakh	0	100±15	260±20	240±30	440±80
	Russian	0	0	0	0	0
Sour milk	Kazakh	30±4	180±10	170±15	350±50	260±30
	Russian	45±10	65±13	80±15	*100± 15*	*80± 20*
Cottage cheese[e]	Kazakh	35±3	80±10	55±10	55±15	115±30
	Russian	*12±3*	25±3	45±5	45±15	25±5
Sour cream[e]	Russian[f]	*30±10*	23±7	30±7	20±4	*20± 8*

[a] Arithmetic mean ± standard error of the mean among children for whom consumption rate of that type of dairy product was reported.

[b] Numbers indicated in Italic based on answers from fewer than 10 children.

[c] Based on answer of one woman.

[d] No numerical data were provided by focus group participants on consumption rate on that type of dairy product.

[e] Units are (g d^{-1}).

[f] Only for village Kanonerka.

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Table 7

Fraction of women who consumed milk and milk products in the 1950s during pregnancy and breast feeding and daily consumption[a,b] derived from the focus group and key informants data.

Dairy product	Ethnicity	Pregnancy		Breast feeding	
		Fraction (%)	Consumption rate (mL d^{-1})	Fraction (%)	Consumption rate (mL d^{-1})
Cow milk	Kazakh	85	*460± 55*	21	360±80
	Russian	100	*920± 130*	48	470±65
Goat milk	Kazakh	17	*235± 110*	0	0
	Russian	0	0	0	0
Sheep milk	Kazakh	25	*325± 110*	2	*250* [c]
	Russian	0	0	0	0
Mare milk	Kazakh	69	*410± 65*	8	*340± 110*
	Russian	0	0	0	0
Cow milk with tea	Kazakh	NA[d]	NA	96	200±30
	Russian	NA	NA	92	100±13
Koumiss	Kazakh	83	*530± 80*	46	440±60
	Russian	0	0	0	0

[a] Arithmetic mean ± standard error of the mean among women who reported consumption rate of that type of dairy product.

[b] Numbers indicated in Italic based on answers from fewer than 10 women.

[c] Based on one answer.

[d] No inquiry made.

Table 8

Characteristics of breastfeeding.

Characteristics	Kazakh	Russian
Fraction (%) of children breastfed	96	100
Duration of breast feeding[a] (mo)	18±0.6	15±0.8
Fraction (%) of children aged less than 1 y for whom other food besides breast milk was introduced	34	71
Age of introduction of other food besides breast milk (mo)	6±0.5	8±0.5

[a] Arithmetic mean ± standard error of the mean among children for whom breast feeding was reported

Table 9

Selected details on preparation of milk products[a].

Milk products	Time required for preparation of milk products (h)		Amount of milk products produced from 1 L of fresh milk (L or kg)	
	Kazakhs	Russians	Kazakhs	Russians
Koumiss	19±1.7	-	1	-
Sour milk	4±1	24±3	1	1
Cottage cheese	9±3	30±4	0.4±0.04	0.2±0.01

[a] Arithmetic mean ± standard error of the mean

Table 10

Summary of agricultural practices in August–November in the 1950s.

Predominant ethnicity in village	Dairy animal	Period of pasturing on local pastures	Location of pastures	Consumption of pasture grass (kg d^{-1}, fresh weight)	Milking period
Kazakh	Cow	through 1 December	2–10 km around village	16/15[a]	all time
	Goat	through 1 December	2–10 km around village	4	all time
	Sheep	through 1 December	2–10 km around village	5	August
	Mare	through 15 September[b]	in village and 1–2 km around	19	through 15 September
Russian	Cow	through 15 November	2–5 km around village[c]	20/15[a]	all time
	Goat	through 15 November	2–5 km around village	4	did not milk
	Sheep	through 15 November	2–5 km around village	5	did not milk
	Mare	through 15 November	2–5 km around village	25	did not milk

[a] August–September/October–November.

[b] In the middle of September mares (horses) are moved to distant pastures 30–100 km away from the village.

[c] In Dolon pastures located only to the west and north from the village.