BREASTMILK CONTAMINATION IN KAZAKSTAN: IMPLICATIONS FOR INFANT FEEDING

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1. Introduction

Numerous reports have highlighted the profound health and economic consequences of environmental degradation in the former Soviet Union (1). The consequences for maternal and child health—and specifically for breastmilk contamination—are of particular concern in the newly independent Republic of Kazakstan (2). Kazakstan borders the Aral Sea, an internationally recognized ecological disaster area (3); is home to Semipalatinsk, the former Soviet nuclear testing site; and, has numerous plants for chemical synthesis, metal mining and milling, weapons manufacture, and petrochemical exploration and refineries. The present study was undertaken to assist the Ministry of Health in making infant feeding recommendations by analyzing breastmilk for chlorinated compounds (chlorinated pesticides, PCBs, and dioxins and furans), toxic metals, and radionuclides (4).

Exposure to environmental contaminants through breastmilk poses a unique public health challenge because the health risks to the infant from such exposure can only be reduced by reducing breastfeeding, which also poses health risks (5). Breastfeeding has a strong protective effect on infant morbidity and mortality in both developing (6-8) and developed countries (9). However, comparing the risks of exposure to contaminants through breastmilk to the risks of not being breastfed was not possible in Kazakstan because of the dearth of scientific information about environmental contamination in general, and about breastmilk contamination in particular (10).

2. Population and Methods

Sampling sites were selected to provide a profile of high-risk exposures to possible contaminants. Samples were collected in two phases. Phase I focused on chlorinated contaminants and was conducted in 7 sites in Central and Southern Kazakstan in 1994. Phase II focused on toxic metals and radionuclides and was conducted in 8 sites in Central and Northern Kazakstan (including Semipalatinsk) in 1995. Because many of the contaminants under study are ubiquitous, protocols for sample collection and analysis specified by WHO (11) and WHO/IAEA (12) were used to ensure that study results would be directly comparable with international data.

Clinic personnel contacted women who met the following selection criteria: 1) first lactation; 2) infant 2 to 8 weeks of age for Phase I or 2 to 20 weeks of age for Phase II; and, 3) mother and infant apparently healthy. For Phase I, clinic personnel were asked to contact every women who met the selection criteria; for Phase II they were asked to contact every other woman. In most clinics, all women who met this selection criteria participated and within-clinic selection bias was minimal.

Analytic protocols require 100 ml of breastmilk for analysis of chlorinated pesticides, dioxins and furans, and PCBs, and 10 ml for analysis of chlorinated pesticides only. Because not all women were able to provide 100 ml at a single sitting, a pooling strategy, as recommended by WHO, was developed. Breastmilk samples were pooled within clinics and ethnic groups. Fish consumption and maternal residential and occupational history were also used as criteria for pooling. A total of 92 women were sampled in Phase I providing a total of 40 samples for analyses of PCBs, dioxins, and furans and 101 samples for analysis of chlorinated pesticides. In Phase II, between 12 and 17 samples per site were collected. At each site, breastmilk samples were pooled to create three pooled samples for radionuclide analysis.

All women invited to participate signed a letter of informed consent, which, was previously unknown in Kazakstan. Rigorous collection protocols were followed by the study team to ensure samples were not contaminated during collection. In Phase I, breastmilk (20 to 100 ml) was hand expressed into 4 oz glass jars with teflon-lined lids certified to be chemically-free of the contaminants under study. Women were required to wash their breasts with soap if they reported using creams or lotions on their nipples. In Phase II, breastmilk (approximately 50 ml) was hand expressed into 2 oz plastic containers through plastic funnels, acid washed to be free of the contaminants under study. Women were required to wash their hands and breasts with purified water. Immediately after collection, samples were frozen and sent to the U.S. for analysis.

For Phase I, target chemicals included the 17 2,3,7,8-substituted dioxins and furans and the 10 homologue groups of tetra- to octa-substituted dioxins and furans; selected tri- to deca-substituted PCBs, including the most toxic coplanar and mono-ortho PCBs; and, 23 commonly detected chlorinated pesticide residues, including the DDT, chlordane, and hexachlorocyclohexane (HCH) families. Analyses were conducted on whole milk. The lipid content of each sample was determined, and the contaminant levels were expressed on a fat-weight basis.

For Phase II, the target metals were aluminum, antimony, arsenic, beryllium, cadmium, lead, mercury, nickel, thallium, and chromium, an essential trace element that can be toxic at high concentrations. The target element for radioactivity analysis was Cesium-137.

State-of-the-art analytic methods were used in the analysis: chlorinated compounds were analyzed by High Resolution Gas Chromatography-High Resolution Mass Spectrometry; metals were analyzed by Inductively-Coupled Plasma Mass Spectrometry, Inductively-Coupled Plasma Atomic Emission Spectrometry, and/or Neutron Activation Analysis; Cesium-137 was analyzed in a high sensitivity HPGe detector with a detection limit of 0.1 Bq (2.8 pCi).

3. Results

Maternal and infant characteristics for both Phase I and II are similar, except for a greater mean weight of Phase II infants, which reflects the different age distribution. Maternal body mass index, weight gain during pregnancy, and infant birthweights were all within normal ranges.

The 40 samples (17 individual and 23 composite samples) analyzed for dioxins had a mean concentration of TCDD, one of the potentially most carcinogenic dioxin congeners, of 13.6 pg/g fat (median 5.4 pg/g fat) (Table 1). Six samples were particularly high in TCDD (19.6 to 118.2 pg/g fat) and represent 6 of the 8 samples collected from two cotton-growing districts in the south, near Uzbekistan. None of the other sites showed similar high levels of this congener. The International Toxic Equivalent Quotient (I-TEQ) indicates a mean concentration of 20.1 pg/g fat (median 11.9

pg/g fat). However, the 6 samples with high concentrations of TCDD, had a mean I-TEQ of 70.0 pg/g fat.

The mean concentration of total PCBs was 410 ng/g fat. Concentrations of six PCB congeners (# 28, 52, 101, 138, 153, 180), summed as an indicator of overall contamination, were between 100 and 350 ng/g fat. The mean concentration for the proposed PCB-TEQ for three coplanar PCBs (# 77, 126, 169) was 9.1 pg/g fat. All PCB-TEQ concentrations in this study were less than the range of concentrations observed in Europe (25), with the exception of one of the samples also high in TCDD that contained 44 pg/g fat. Among the chlorinated pesticide residues, only α, β-, and γ-HCH, DDE (2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane), DDT, and hexachlorobenzene (HCB) were detected.

Among the toxic elements, the median concentrations observed at each site were within the range of median concentrations in other countries reported by WHO/IAEA (12) and/or other sources of international data. None of the samples had Cesium-137 present.

4. Discussion

In general, the results of this study show concentrations of contaminants in breastmilk in Kazakstan similar to those found in Europe. Concentrations of toxic metals are consistent with the range of concentrations observed in other countries. Radioactivity was not detected in any samples. Total PCBs, the proposed PCB-TEQ of coplanar PCBs, and six PCBs summed as an indicator of overall contamination were all below or on the low range of European concentrations. Many chlorinated pesticide residues commonly seen in Europe were not detected in any samples. With three important exceptions, concentrations of contaminants are similar to or lower than those in Europe. These exceptions are localized contamination with the most toxic dioxin congener, TCDD, and generalized contamination with β-HCH and DDT. The localized high concentrations of TCDD are of particular concern as they are higher than in Europe (13) and Russia (14), comparable only to breastmilk collected during the early 1970s in South Vietnam and recently analyzed (15).

Infant exposure to chlorinated compounds through breastfeeding is a function of the concentration of a particular contaminant in breastmilk and the volume of breastmilk consumed over the course of lactation. Concentrations are highest in women breastfeeding for the first time, and for many contaminants, concentrations decrease over the course of lactation as breastfeeding is the main route of excretion (16). The volume of breastmilk ingested per day is generally high during the period of exclusive or full breastfeeding (about 120 ml/kg body weight/day) and gradually decreases as complementary foods are introduced. The exact volume depends on the specific infant feeding patterns and, in particular, on the durations of exclusive (defined as breastmilk as the sole source of food) and any breastfeeding. Representative data on infant feeding practices in Kazakstan show that although 96 percent of women initiate breastfeeding and breastfeed for a long period of time, few exclusively breastfeed (17). The median durations of exclusive and any breastfeeding are 0.4 and 13.9 months, respectively. Thus, even though infants are potentially exposed to contaminants in breastmilk over a long period of time, daily exposures are less than calculated for an exclusively breastfed infant because breastmilk is rarely their only source of food.

The median I-TEQ concentration in Kazakstan results in a daily intake of dioxins and furans of 50.1 pg/kg body weight for an exclusively breastfed infant and 25 pg/kg body weight for a partially breastfed infant (Table 2). Although these exposures greatly exceed the maximum exposure of 10 pg/kg/d used by some European government agencies (as cited in 18), they are similar to exposures in Germany showing a daily intake of dioxins and furans of 71 pg/kg body weight for an exclusively breastfed infant, calculated from an I-TEQ in breastmilk of 16.9 pg/g fat (19). Based on Western

European concentrations of dioxins, a WHO/EURO expert group recommends continuation and promotion of breastfeeding (13). Median concentrations of TCDD and DDT in Kazakstan are similar to the concentrations of this contaminant used by Rogan et al., in their analysis of mortality risks and benefits of breastfeeding (5). Rogan et al. concluded that the estimated changes in life expectancy from cancer because of exposure to these contaminants through breastmilk was less than 3 days compared to an increase in life expectancy from breastfeeding of 70 days. Comparison of the median concentrations of TCDD and DDT in Kazakstan to median concentrations used in both these analyses indicates that breastfeeding should not be discouraged. The median I-TEQ concentration for infants receiving breastmilk from the samples high in TCDD results in a daily intake of dioxins and furans of 216 and 108 pg/kg body weight for an exclusively and partially breastfed infant, respectively. Rogan's model was replicated to calculate the risks of breastfeeding for the high TCDD districts (also taking into account other chlorinated exposures). This analysis also shows that life expectancy is greater for breastfed infants, taking cancer risks into account.

Concentrations of β-HCH (2210 ng/g fat) exceed the current median concentration for Europe (200 ng/g fat), but are comparable to recently reported concentrations for Russia (14). Similarly high concentrations were detected in France (1,000 to 2,000 ng/g fat) and Japan (650 to 4,780 ng/g fat) in the early 1970s, and in the 1980s in India and China (1,000 to 19,000 ng/g fat) (16). The median concentration of β-HCH corresponds to a daily intake of 7,014 ng/kg body weight for an exclusively breastfed infant and 3,507 ng/kg body weight for a partially breastfed infant (Table 3). The infant feeding implications of these β-HCH concentrations are unclear, as WHO has not set Acceptable Daily Intakes and no recommendations regarding breastfeeding for this pesticide are available. Because a criterion for entry to the study was that the mother and infant were "apparently healthy," there is no evidence of acute toxic effects associated with present concentrations. Similar concentrations have been observed historically in Europe and Asia and adverse effects associated with breastfeeding have not been reported. The mean concentration total DDT of 1,730 ng/g fat is twice current background concentrations in Europe (16) but is similar to historical concentrations. Total DDT concentrations in Kazakstan correspond to a calculated daily intake by a fully breastfed infant of 7,266 ng/kg body weight and a partially breastfed infant of 3,633 ng/kg body weight. For an exclusively breastfed infant, this is less than half of the Acceptable Daily Intake for total DDT of 20,000 ng/kg body weight/day (20).

Based in part on the results of this study, the Ministry of Health is promoting breastfeeding (21). Recent reports suggest possible adverse developmental outcomes associated with TCDD exposure (22-24). Further epidemiological research is needed to examine the relationship between TCDD exposure and infant and child development in the two districts with high breastmilk concentrations.

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Table 1: TCDD, I-TEQ, and PCB-TEQ from breastmilk* (pg/g fat)

	TCDD	I-TEQ	PBC-TEQ
Samples (n=40)	13.6 (1.2 - 118.2)** 5.4***	20.1 (4.2 - 132.9) 11.9	9.1 (4.9 - 44.4) 7.6
Individual samples (n=17)	17.1 (1.3 - 118.2) 6.7	23.8 (4.2 - 127.3) 12.7	11.3 (4.1 - 44.4) 9.4
Pooled samples (n=23)	11.3 (2.6 - 117.1) 5.2	17.8 (4.7 - 132.9) 11.0	8.1 (4.9 - 12.8) 7.6
Samples high in TCDD (n=6)	57.8 (19.6 - 118.2) 35.5	70.0 (27.8 - 132.9) 51.5	12.6 (4.9 - 44.4) 6.7
European data (range of regional means)	1.4 -4.5(a)	15 - 36 (a) 5 - 53 (b) 9 - 27 (c)	0.8 - 16.1 (c)

* Breastmilk averaged 3.5% fat.
** Mean (range); *** Median
(a) reference 13; (b) reference 19; (c) reference 25.

Table 2: Daily Intake of Selected Chlorinated Contaminants by Breastfed Infants*

	Exclusive	Partial
Total DDT**(ng/kg)	7,266 (1,323 - 48,594)***	3,633 (661.5 - 24,297)
HCB****(ng/kg)	328 (25 - 1,848)	163.8 (12.6 - 924)
beta-HCH (ng/kg)	7,014 (1,806 - 3,616)	3,507 (903 - 18,081)
Total PCBs (ng/g)	1,424 (627 - 5,662)	712.8 (313.3 - 2,830.8)
TCDD (pg/kg)	22.7 (5.3 - 496.5)	11.4 (2.7 - 248.3)
I-TEQ (pg/kg)	50.1 (17.6 - 558.1)	25 (8.8 - 279.1)

*Assuming an intake of 120 ml/kg/d for a fully breastfed infant and 60 ml/kg/d for a partially breastfed infant and a 3.5 % fat content of breastmilk.
**Acceptable Daily Intake (ADI) for total DDT is 20,000 ng/kg/d (20).
***Median (range).
****WHO has not set ADIs for HCB, PCBs, TCDD, and I-TEQs.