

Dioxins and furans in breast milk: a case study of mothers from southern Rio de Janeiro, Brazil

PCDD/Fs e dl-PCBs no leite materno. Estudo de caso: parturientes de municípios pertencentes à área industrial do Sul Fluminense, Brasil

PCDD/Fs y dl-PCBs en leche materna. Estudio de caso: madres de municipios pertenecientes a la zona industrial del sur de Río de Janeiro, Brasil

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Abstract

A study of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (dl-PCBs) was conducted in a pooled sample of breast milk from 27 primiparous mothers living in 12 locations in the meso-region industrial area of southern Rio de Janeiro, Brazil, between August 2012 and July 2013. Questionnaires with questions regarding food habits, social and economic conditions and places of dwelling were applied. Milk was collected between four and six weeks after delivery from mothers who were breastfeeding only one infant. The toxic equivalency (TEQ) of PCDD/Fs, and dl-PCBs were 10.6, 4.77, 6.96 TEQ pg/g, respectively. The understanding and identification of pollution sources may be helpful for applying better counter measures against breast milk dioxin contamination. It is important for pregnant women to have a diet that is as free as possible from chemical contaminants. Further research must be undertaken in the context of epidemiological investigations to more accurately assess the effects of these compounds. The background contamination by PCDD/Fs, and dl-PCBs in mothers living at industrial area in Rio de Janeiro is lower than that generally found in industrialized countries.

Dioxins; Furans; Human Milk; Environmental Exposure

Resumo

Um estudo sobre PCDD/Fs e dl-PCBs foi realizado em uma amostra combinada de leite materno de 27 mães primíparas, moradoras dos 12 municípios que compõem o polo industrial da mesorregião fluminense, Brasil, entre agosto de 2012 e julho de 2013. Questionários com perguntas a respeito de hábitos alimentares, condições sociais e econômicas, e locais de habitação foram aplicados. As mães amamentavam apenas um bebê e as amostras de leite foram coletadas entre 4 e 6 semanas após o parto. Os níveis de PCDD/Fs e dl-PCBs foram de 10,6, 4,77 e 6,96 pg TEQ/g, respectivamente. A compreensão e identificação de fontes de poluição podem ser úteis para as medidas contra a contaminação com dioxinas do leite materno. É importante para as mulheres grávidas ter uma alimentação mais livre possível de contaminantes químicos. Pesquisas complementares devem ser realizadas para avaliar com mais precisão os efeitos desses compostos. A contaminação circunstancial por PCDD/Fs e dl-PCBs em mães que vivem em área industrial no Rio de Janeiro é menor do que geralmente é encontrado nos países industrializados.

Dioxinas; Furanos; Leite Humano; Exposição Ambiental

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Introduction

Contaminations by polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs), closely related groups of chemical byproducts that are produced throughout the world and globally distributed in the environment, have been of great concern due to their endocrine disrupting effects on humans and wildlife¹. Chemically stable and lipophilic properties of these contaminants led to their high contamination in higher trophic biota, including human². Despite the intensive monitoring efforts and anticipated results of decreasing trends of persistent organic pollutants (POPs) in developed countries as a consequence of their regulation on use and waste treatment, little information is available on their contamination status in developing countries even though these chemicals are still being used and unintentionally produced in several parts of these countries.

Dioxins and furans are among the most hazardous chemicals known: extremely tiny doses have been shown to cause negative health effects³. These chemicals are listed by several governmental agencies as known causes of cancer in humans⁴. A small share of the dioxins and furans released into the environment are broken down by sunlight, but most persist by attaching to soil particles and sediment in water. Once attached to such particles, they enter the food chain, leading eventually to bioaccumulation in animal fat⁵. Indeed, studies have linked dioxins and furans to many adverse effects on human health, such as carcinogenicity, immunotoxicity and neurotoxicity^{1,4}. Dioxins and furans are attracted to fat, resistant to metabolism, and have a lipophilic nature which allows accumulation in human tissues⁶. Within the human body, the highest levels of these chemicals are in fat and breast milk. These compounds are lipid-soluble, poorly eliminated and are therefore accumulated and stored in human adipose tissues. They can pass through the placenta causing exposure of the foetus, and their existence in human milk exposes infants during the lactating period.

Human beings can be exposed to dioxins and furans in a number of ways. Eating contaminated food (primarily meat, dairy products, and fish) is the major path for dioxin exposure³, but other less common routes of exposure include contact with certain pesticides and herbicides (such as the wood preservative pentachlorophenol, and the phenoxy herbicides), or working in industries that produce dioxin and furan byproducts⁷.

Dietary exposure makes up more than 90 percent of human dioxin and furan intake³. Fatty

foods usually contain more significant levels because they are higher up the food chain and thus have accumulated more dioxin. Once dioxins and furans have entered animal tissues, they have few opportunities to leave, so the chemicals can persist for many years. In lactating women, dioxins and furans may leave the body in breast milk. As with many other persistent chemicals that appear in breast milk, the concentration of dioxins and furans changes with time^{8,9}.

In order to quantify the consumption by infants of the contaminants studied, their intake through breast milk was estimated. In fact, in many cases, since human milk is the only food that newborns consume in the first months of life, such an analysis makes it possible to estimate the intake of xenobiotics in a more simple and accurate manner than can be done in organisms with a more complex diet. In this study, the presence and levels of some classes of organochlorinated compounds were evaluated in samples of breast milk. In this paper data are presented on the levels of PCDD/Fs and dioxin-like PCBs in a pooled sample of breast milk from 27 mothers living at 12 locations in a meso-region industrial center of southern Rio de Janeiro, Brazil.

Materials and methods

Sampling collection

Human breast milk samples were collected from mothers living in 12 different areas of a meso-region industrial area (Angra dos Reis, Barra do Pirai, Barra Mansa, Itatiaia, Parati, Pinheiral, Pirai, Porto Real, Quatis, Resende, Rio Claro, Rio das Flores, Valença, and Volta Redonda), in southern Rio de Janeiro, between August 2012 and July 2013. A detailed questionnaire was given to obtain an informative record of the participants. Before giving milk, each mother completed an informed consent form. Breast milk samples were collected by manual expression and pooling of individual samples was done on a volume basis by taking 10mL of collected milk from each donor so that a final volume of 270mL was gathered. All samples were collected between four and six weeks after delivery.

Sample preparation and extraction

Fat extraction was performed using the BLH-IFF/NT – 30.05 method⁷. The extraction of the human breast milk samples procedure followed the method described by Horii et al.⁸.

Analysis

Gas chromatography (GC) analyses were performed on a CP-3800 GC equipped with a CP-8400 autosampler (Varian Inc., Walnut Creek, USA). The toxic equivalency (TEQ) of the dioxin analogues in the analyzed samples was calculated using toxic equivalency factors (TEF) ⁹.

Results

The donors ranged in age from 18 to 32 years (median: 23 years) and all 27 of them were primiparous. All mothers provided a detailed list of dietary habits. All donors had been living in the study area for at least five years before milk collection.

Tables 1 and 2 shows the levels of PCDD/Fs, and dl-PCBs congeners and total TEQs found in this pooled sample of mothers' milk from twelve locations related to the area under study. The average TEQs of PCDDs, PCDFs, dioxin-like PCBs were 10.6, 4.77, 6.96 TEQ pg/g fat.

Discussion and conclusion

Breast milk is the most complete food for newborns because its nutritional composition is essential for the physical and mental development of the child ⁵. Due to this sole source of food and the fact that at this stage many organs are still in development, newborns seem to be the group most vulnerable to organochlorinated compounds.

The participants' diet did not seem to differ much between the areas under study. It was a mixed diet with consumption of meat, fish, milk, and dairy products. The evaluation of the relationship obtained in questionnaires related to eating habits and its influence on breastfeeding and since we obtained positive results for PCDD/Fs and dl-PCBs, no significant effect for babies was observed, as shown in Tables 1 and 2.

A number of animal and human studies have looked at the health effects of dioxins and furans on children's health from in utero and postnatal exposure. Health outcomes that were evaluated have included low birth weight, hormone fluctuation, neurobehavioral function, and altered immune function ⁹. Thus far, the studies have not identified any links between these health effects and exposure to dioxins specifically from breast milk.

Overall, the literature reviewed provides data on PCDD/Fs, and dl-PCBs in human milk in several countries. Compared to other studies in Bra-

Table 1

PCDD/Fs concentrations (pg/g fat) and total TEQs (TEQ pg/g fat) in pooled breast milk samples from an industrial center. Rio de Janeiro, Brazil.

Congener	pg/g fat
Dibenzo-p-dioxins (PCDD)	
2378-TCDD	1.27
12378-PeCDD	6.19
123478-HxCDD	0.54
123678-HxCDD	22.47
123789-HxCDD	7.22
1234678-HpCDD	8.60
OCDD	77.27
Total PCDDs TEQs	10.60
Dibenzofurans (PCDF)	
2378-TCDF	1.18
12378-PeCDF	0.49
23478-PeCDF	12.48
123478-HxCDF	3.31
123678-HxCDF	3.22
1234789-HxCDF	0.18
234678-HxCDF	2.02
1234678-HpCDF	1.99
1234789-HpCDF	0.00
OCDF	0.73
Total PCDFs TEQs	4.77
Total TEQs (PCDDs + PCDFs)	15.37

Table 2

dl-PCBs concentrations (pg/g fat) and total TEQs (TEQ pg/g fat) in pooled breast milk samples from an industrial center. Rio de Janeiro, Brazil.

Congener	pg/g fat
Non-ortho PCBs	
3,3',4,4'-TCB (77)	36.50
3,4,4',5-TCB (81)	24.74
3,3',4,4',5-PeCB (126)	60.70
3,3',4,4',5,5'-HxCB (169)	38
Mono-ortho PCBs	
2',3,4,4',5-PeCB (123)	34.29
2,3',4,4',5-PeCB (118)	9067
2,3,3',4,4'-PeCB (105)	1,842
2,3,4,4',5-PeCB (114)	891
2,3',4,4',5,5'-HxCB (167)	1,034
2,3,3',4,4',5-HxCB (156)	2,897
2,3,3',4,4',5'-HxCB (157)	879
2,3,3',4,4',5,5'-HeCB (189)	249
Total dioxin-like PCBs TEQs	6.96
Total dioxin TEQs	22.33

zil, our results were lower than those for mothers living in more industrialized countries^{2,4,5,6}, but comparable to mothers in the city of Rio de Janeiro¹⁰.

A child who eats human milk is at the apex of the food chain and thus can receive a higher burden of contaminants eliminated by this pathway, especially those capable of undergoing the phenomenon of biomagnification^{4,9}. Children are particularly vulnerable to chemical agents present in the environment due to their physiological characteristics. Thus, dioxins, furans and polychlorinated biphenyls in air, water, soil, and food are more likely to be absorbed by children than for adults. Human milk is an important vehicle for elimination of xenobiotics from the

body and may constitute a source of contamination for infants⁶.

PCDD/Fs and dl-PCBs bioaccumulation in the food chain has been shown to cause a number of toxic biological responses, which makes environmental and human exposure a focus for global concern. In particular, fish, meat, and milk are rich in dioxins due to their accumulation in tissue lipid. While the benefits of breastfeeding outweigh the risks from contaminants in human milk, it is extremely important to continuously identify these compounds in breast milk. In conclusion, this study suggests that it is important for pregnant women to have a balanced diet to mitigate the exposure of their infants to chemicals.

Resumen

Un estudio de PCDD/Fs y dl-PCBs se llevó a cabo en una muestra combinada de leche materna de 27 madres primíparas, residentes en 12 barrios que componen la zona industrial sur de Río de Janeiro, Brasil, entre agosto de 2012 y julio 2013. Se aplicaron cuestionarios con preguntas relacionadas con los hábitos alimentarios, condiciones socioeconómicas y lugares de vivienda. Se recogieron muestras de leche entre 4 y 6 semanas después del parto. Los niveles de PCDD/Fs y dl-PCBs fueron 10,6, 4,77 y 6,96 pg TEQ/g, respectivamente. La comprensión y la identificación de las fuentes de contaminación pueden ser útiles para la toma de medidas con-

tra la contaminación por dioxinas en leche materna. Es importante que las mujeres embarazadas tengan un suministro lo más libre posible de contaminantes químicos. Deben llevarse a cabo más investigaciones para evaluar con mayor precisión los efectos de estos compuestos. La contaminación circunstancial por PCDD/Fs y dl-PCBs en madres que viven en el área industrial de Río de Janeiro es inferior a la que generalmente se encuentra en los países industrializados.

Dioxinas; Furanos; Leche Humana; Exposición a Riesgos Ambientales

Contributors

A. P. Ferreira contributed to the composition of the database, analysis and writing of the paper. M. F. R. Moreira helped in guiding the development and execution of the analysis, correction and writing of the paper.

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