Per- and Polyfluorinated Compounds in Blood and their Impact on Respiratory Problems in Young Children in Winnipeg, Manitoba

by

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Abstract

Per- and polyfluorinated compounds (PFCs) are known to be toxic, bioaccumulative, and persistent. However, exposure routes and toxic effects in humans are still widely unknown. The concentrations of 17 PFCs were measured in newborn cord blood plasma and plasma from pre- and postnatal women from Winnipeg, Manitoba using online solid phase extraction coupled with liquid chromatography mass spectrometry. Median concentrations (with standard deviation) were 2.2 ng/mL (1.8 ng/mL) for perfluorooctanesulfonic acid (PFOS) and 0.89 ng/mL (0.75 ng/mL) for perfluorooctanoic acid (PFOA) in prenatal maternal plasma and 1.8 ng/mL (1.8 ng/mL) for PFOS and 0.55 ng/mL (0.46 ng/mL) for PFOA in postnatal maternal plasma. Multiple linear regression and principal component analysis were used to evaluate possible associations of maternal and infant characteristics with PFC concentrations. In general, concentrations of PFCs in plasma were associated with maternal characteristics, but not home characteristics, wheezing, or developmental effects.

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Table of Contents

Abstract II

Acknowledgements III

List of Tables IX

List of Figures XI

List of Copyrighted Material for which Permission was Obtained XIII

List of Abbreviations XIV

Chapter 1 Introduction to PFCs, their Toxic Effects, and Exposure Routes 1

1.1. Introduction to this Thesis 1

1.2. Importance of PFCs 2

1.3. Physical Properties 6

1.3.1. Degradation 9

1.4. Production 13

1.5. Commercial Applications and Uses 15

1.6. Analytical Methods of Analyzing PFCs in Blood 16

1.7. PFCs in the Human Body 19

1.7.1. PFC Concentrations in Canadian Blood Samples 21

1.7.2. Localization and Elimination in the Human Body 22

1.8. Exposure 24

1.8.1. Prenatal Exposure 24

1.8.2. Human Breast Milk 30

1.8.3. Infant Formula 35

1.8.4. Household Air and Dust 37

1.9. Toxicity 38

1.9.1. Brain Development 39

1.9.2. Effects on Thyroid Hormones 40

1.9.3. Effects on Body Weight 41

1.9.4. Gestational Effects 44

1.9.5. Liver Weight Changes 45

1.9.6. Activation of Peroxisome Proliferation Activated Receptors 46

1.9.7. Lungs 47

1.10. Summary of Chapter 1 49

1.11. References 50

Chapter 2 Evaluation of PFC Concentrations in Human Plasma and Associations of PFC Concentrations with Maternal, Infant, and Home Characteristics 77

2.1. Introduction 77

2.2. Methods and Materials 81

2.2.1. Chemicals and Reagents 81

2.2.2. Sample Collection 83

2.2.3. Standards and Sample Preparation 84

2.2.4. Instrumental Analysis 85

2.2.5. Statistical Analysis 90

2.3. Results and Discussion 91

2.3.1. Method Validation 91

2.3.2. Concentrations of PFCs in Plasma 107

2.3.3. Distributions and Correlations between PFCs in Plasma 125

2.3.4. Exposure and Trends of PFCs from Maternal and Home Characteristics 134

2.3.5. PFC Concentrations in Plasma and Incidence of Wheezing in Infants 153

2.3.6. Aspects of Fetal Growth 155

2.4. Summary of Chapter 2 157

2.5. References 158

Chapter 3 Conclusions and Future Directions 177

3.1. References 180

Appendices 184

Appendix A: Concentrations of PFCAs and PFSAs in maternal plasma during pregnancy (ng/mL). 185

Appendix B: Concentrations of 8:2 FTUCA, FOSAs, and FOSEs in maternal plasma during pregnancy (ng/mL). 217

Appendix C: Concentrations of PFCAs and PFSAs in maternal plasma one year after delivery (ng/mL). 237

Appendix D: Concentrations of 8:2 FTUCA, FOSAs and FOSEs in maternal plasma one year after delivery (ng/mL). 257

Appendix E: Concentrations of PFCAs and PFSAs in cord blood plasma (ng/mL). 269

Appendix F: Concentrations of 8:2 FTUCA, FOSAs and FOSEs in cord blood plasma (ng/mL). 273

Appendix G: PCA factor scores for maternal plasma during pregnancy and one year after delivery. 276

Appendix H: Total n values for infant characteristics used to evaluate prenatal maternal plasma. Notes for columns are described at the bottom of the table. 308

Appendix I: Infant characteristics for individual samples used to evaluate prenatal maternal plasma. Units and notes for columns are described at the bottom of the table.. 309

Appendix J: Total n values for infant characteristics used to determine the modified asthma predictive index with prenatal plasma. Notes for columns are described at the bottom of the table. 342

Appendix K: Infant characteristics for individual samples used to determine the modified asthma predictive index using prenatal plasma. Notes for columns are described at the bottom of the table. 343

Appendix L: Total n values for prenatal maternal characteristics used to evaluate prenatal maternal plasma. Notes for columns are described at the bottom of the table. 351

Appendix M: Prenatal maternal characteristics for individual samples used to evaluate prenatal maternal plasma. Units and notes for columns are described at the bottom of the table. 352

Appendix N: Total n values for home characteristics used to evaluate prenatal maternal plasma. Notes for columns are described at the bottom of the table. 373

Appendix O: Home characteristics for individual samples used to evaluate prenatal maternal plasma. Units and notes for columns are described at the bottom of the table. 374

Appendix P: Total n values for postnatal maternal characteristics used to evaluate maternal plasma one year after delivery. Units and notes for columns are described at the bottom of the table. 395

Appendix Q: Postnatal maternal characteristics for individual samples used to evaluate maternal plasma one year after delivery. Units and notes for columns are described at the bottom of the table. 396

Appendix R: Total n values for home characteristics used to evaluate maternal plasma one year after delivery. Notes for columns are described at the bottom of the table..... 409

Appendix S: Home characteristics for individual samples used to evaluate maternal plasma one year after delivery. Units and notes for columns are described at the bottom of the table..... 410

List of Tables

Table 1.1. List of PFCs used in this project, their abbreviations, and structures. 3

Table 1.2. Partitioning constants of five PFCs. 8

Table 1.3. Mean or median concentrations (ng/mL) of PFCs in cord blood from various countries. 26

Table 1.4. Concentrations of PFOS and PFOA in human breast milk (ng/L) for various countries. 32

Table 1.5. Tolerable daily intake values (ng/kg bw/day) of PFOS and PFOA defined by various organizations/countries. 34

Table 2.1. Positions of the binary pump 10-port valve and composition of solvents used in the liquid chromatography analysis. Acetonitrile is abbreviated as ACN, methanol as MeOH, isopropanol as IPA, and ammonium acetate as AA. 89

Table 2.2. Optimized fragmentor voltage, collision energies, ion transitions and internal standards for each analyte. (Q) indicates the qualifier ion fragment. 92

Table 2.3. Estimated limits of detection and limits of quantification in ng/mL for each analyte in matrix-matched bovine plasma or solvent (instrumental). Matrix-matched LOQs were used for all further plasma analyses. 97

Table 2.4. Mean percent recoveries and percent coefficient of variances for 17 PFCs.. 102

Table 2.5. Interday and intraday precision values for spiked human plasma. 104

Table 2.6. Concentrations (ng/mL) and summary statistics of PFCs of the current study, in prenatal maternal plasma (n = 414). LOQ values in Table 2.3. 108

Table 2.7. Concentrations (ng/mL) and summary statistics of PFCs in maternal plasma of the current study, one year after giving birth (n = 247). LOQ values in Table 2.3. 109

Table 2.8. Mean or median concentrations (ng/mL) of commonly measured PFCS in prenatal maternal blood from various studies and locations. 113

Table 2.9. Concentrations (ng/mL) and summary statistics of PFCs in cord blood of this study (n = 50). LOQ values in Table 2.3. 120

Table 2.10. Median or mean TEs of PFCs in maternal blood to cord blood for various recent studies and this study. Values of "-" were not evaluated. 123

Table 2.11. Median TEs of PFCs in maternal blood to cord blood for this study in relation to their functional group and carbon chain length. 124

Table 2.12. Spearman rank correlation coefficients between maternal blood and cord blood. Values of "-" were not evaluated. 125

Table 2.13. Spearman rank coefficients for PFCs with median values over the LOQ (Table 2.3) in prenatal maternal plasma. Boxes with "-" do not have significant correlation. 127

Table 2.14. Spearman rank coefficients for PFCs with median values over the LOQ (Table 2.3) in maternal plasma one year after delivery. Boxes with "-" do not have significant correlation. 129

List of Figures

Figure 1.1. Biotransformation pathway of FTOHs to produce PFCAs. Reprinted (adapted) with permission from Butt et al., 2010. Copyright (2010) American Chemical Society..... 11

Figure 1.2. Biotransformation pathways of FOSEs and FOSAs to produce PFOS. Reprinted (adapted) with permission from Xu et al., 2004. Copyright (2004) American Chemical Society. 12

Figure 2.1. Schematic of the 6-port switching valve. 88

Figure 2.2. Schematic of the 10-port switching valve. 88

Figure 2.3. LC Chromatogram of PFOS in a maternal plasma sample (transition 498.9 → 80). The linear PFOS peak has a retention time of 5.2 minutes and the suspected PFOS isomer or bile acid has a retention time of 5.0 minutes. 96

Figure 2.4. Chromatogram of a typical prenatal maternal plasma sample (sample identification number (ID) 40600)..... 110

Figure 2.5. Median distributions of PFCs in maternal (prenatal n = 414, postnatal n = 247) and cord blood plasma (n = 50). 128

Figure 2.6. Box and whisker plot of matched prenatal and postnatal samples (n = 161). 132

Figure 2.7. Loadings plot of PC1, PC2, and PC3 for PFCs in maternal plasma. 135

Figure 2.8. Loadings (top) and scores (bottom) plots of PC2 versus PC1..... 136

Figure 2.9. Loadings (top) and scores (bottom) plots of PC3 versus PC1..... 137

Figure 2.10. Loadings plot (top) and scores plot (bottom) of PC3 versus PC2. 138

Figure 2.11. Box and whisker plot of concentration of PFOA versus duration of breastfeeding (n = 168). 144

Figure 2.12. Values of PC2 compared to the number of months breastfed for postnatal participants (n = 168). 145

Figure 2.13. Values of PCs versus the maternal age at time of sampling (n = 413). The p-value indicates the slopes were significantly different than zero. 146

Figure 2.14. Box and whisker plots of maternal age versus number of deliveries for prenatal samples (n = 219). 148

Figure 2.15. Box and whisker plots of PC values versus number of deliveries for prenatal samples (n = 219). Whiskers show the minimum to maximum values. 150

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1. Figure 1.1. Biotransformation pathway of FTOHs to produce PFCAs. Reprinted (adapted) with permission from Butt et al., 2010. Copyright (2010) American Chemical Society.

   Obtained with permission from: Butt, C. M., Muir, D. C. G., & Mabury, S. A. (2010). Elucidating the pathways of poly- and perfluorinated acid formation in rainbow trout. *Environmental Science & Technology, 44*(13), 4978, Figure 3.

2. Figure 1.2. Biotransformation pathways of FOSEs and FOSAs to produce PFOS. Reprinted (adapted) with permission from Xu et al., 2004. Copyright (2004) American Chemical Society.

   Obtained with permission from: Xu, L., Krenitsky, D. M., Seacat, A. M., Butenhoff, J. L., & Anders, M. W. (2004). Biotransformation of N-ethyl-N-(2-hydroxyethyl) perfluorooetanesulfonamide by rat liver microsomes, cytosol, and slices and by expressed rat and human cytochromes P450. *Chemical Research in Toxicology, 17*(6), 773, Figure 8.

List of Abbreviations

1YRM	postnatal maternal plasma
8:2 FTCA	2-perfluorooctyl ethanoic acid
8:2 FTUCA	2*H*-perfluoro-2-decanoic acid
AA	ammonium acetate
ACN	acetonitrile
ANOVA	analysis of variance
BfR	Bundesinstitut für Risikobewertung; German Federal Institute for Risk Assessement
bw	body weight
CD	cord blood plasma
C-section	cesarean section
CHILD	Canadian Healthy Infant Longitudinal Development
EPA	U.S. Environmental Protection Agency
ESI	electrospray ionization
EtFOSA	*N*-ethylperfluoro-1-octanesulfonamide
EtFOSE	2-(ethylperfluoro-1-octanesulfoamido)-ethanol
FOSA	perfluoro-1-octanesulfonamide
FOSA	perfluoroalkysulfonamide
FOSE	perfluorooctanesulfonamido-ethanol
FTOH	fluorotelomer alcohol
GC	gas chromatography
GC-MS	gas chromatography with mass spectrometry

HPLC	high pressure liquid chromatography
ID	identification number
IPA	isopropanol
K_{aw}	air-water partitioning coefficient
kg	kilogram
K_{oa}	octanol-air partitioning coefficient
K_{ow}	octanol-water partitioning coefficient
L	liter
LC	liquid chromatography
LC-MS	liquid chromatography coupled with mass spectrometry
LC-MS/MS	liquid chromatography coupled with tandem mass spectrometry
LOD	limit of detection
LOQ	limit of quantification
m	metre
m/z	mass-to-charge ratio
MeFOSA	*N*-methylperfluoro-1-octanesulfonamide
MeFOSE	2-(*N*-methylperfluoro-1-octanesulfonamido)-ethanol
MeOH	methanol
mL	millilitre
mM	millimolar
MS	mass spectrometry
MS/MS	tandem mass spectrometry
NA	not applicable

N.D.	not detected
ng	nanogram
NHANES	National Health and Nutrition Examination Survey
NMR	nuclear magnetic resonance
PC	principal component
PCA	principal component analysis
PCBs	polychlorinated biphenyls
PFBA	perfluorobutanoic acid
PFBS	perfluoro-1-butanesulfonic acid
PFC	per- and polyfluorinated compound
PFCA	perfluorocarboxylic acid
PFDA	perfluoro-*n*-decanoic acid
PFDS	perfluoro-1-decanesulfonic acid
PFHpA	perfluoro-*n*-heptanoic acid
PFHxA	perfluoro-*n*-hexanoic acid
PFHxS	perfluoro-1-hexanesulfonic acid
PFNA	perfluoro-*n*-nonanoic acid
PFOA	perfluoro-*n*-octanoic acid
PFOS	perfluoro-1-octanesulfonic acid
PFPA	perfluoro-*n*-pentanoic acid
PFSA	perfluorosulfonic acid
PFUA	perfluoro-*n*-undecanoic acid
pg	picogram

P_L	vapour pressure
PNM	prenatal maternal plasma
PPAR	peroxisome proliferator activated receptor
PTFE	polytetrafluoroethylene
Q	qualifier ion fragment
S/N	signal-to-noise ratio
SPE	solid phase extraction
T_3	triiodothyronine
T_4	thyroxine
TDI	tolerable daily intake
TE	transfer efficiency
U.S.	United States of America
UK	United Kingdom
V	volts
µL	microlitre

Chapter 1 Introduction to PFCs, their Toxic Effects, and Exposure Routes

1.1. Introduction to this Thesis

As will be discussed in the following chapter, per- and polyfluorinated compounds (PFCs) are found in maternal and infant blood and can have toxic effects to humans. However, the extent and localization of toxicity in humans is not well understood. Both occurrence of asthma and production of PFCs have followed a similar temporal pattern, and PFCs have shown toxic effects to rodent lungs in laboratory studies. The overall aim of this thesis was to determine the concentrations of PFCs in maternal blood, as well as cord blood; to determine physiological, health-related, and socio-economic factors that may affect levels of PFCs in mothers and their infants; and to investigate whether or not a correlation existed between concentrations in blood and occurrence of symptoms of asthma, such as wheezing, in infants in Winnipeg, Manitoba. To date, no other study in Canada has examined this particular aspect of PFCs in relation to symptoms of asthma. Additionally, this study aimed to investigate possible correlations between developmental effects in infants, home characteristics, and maternal characteristics and PFC levels in blood.

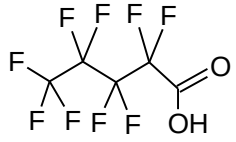
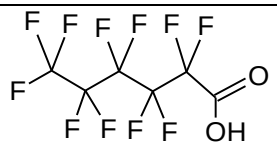
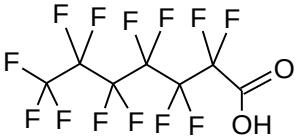
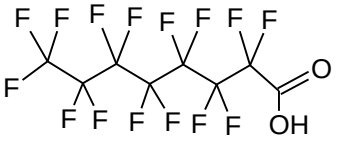
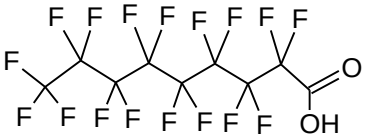
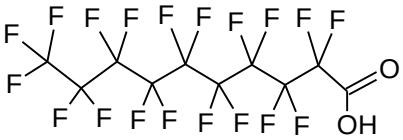
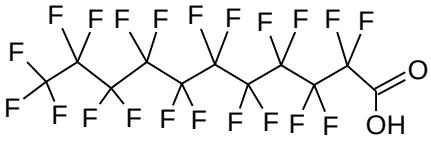
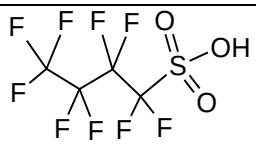
This study is part of the Canadian Healthy Infant Longitudinal Development (CHILD) study. CHILD is an extensive study that follows infants and their parents from pregnancy through the first five years of the child's life and aims to investigate the impacts of environmental factors on health. Blood samples are taken from volunteer parents and their children at various time points and parents fill out extensive surveys regarding health, and characteristics of their lives and their homes. Survey results and blood samples collected by CHILD were used for this study.

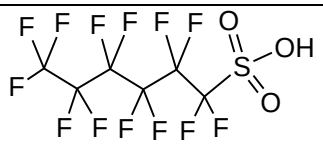
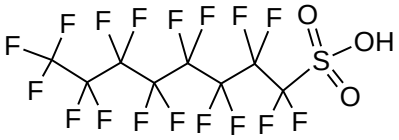
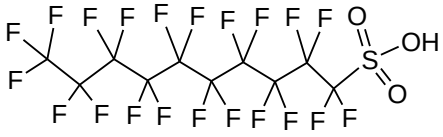
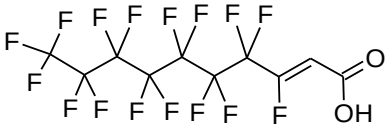
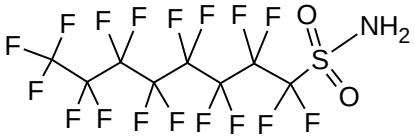
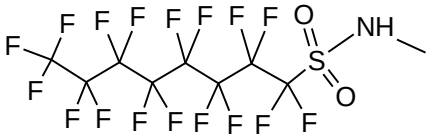
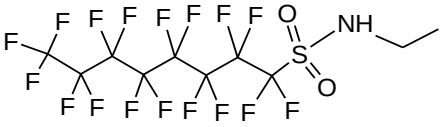
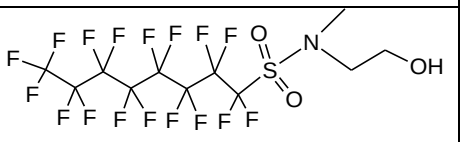
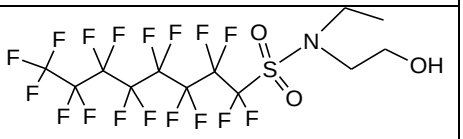
The method developed to analyze blood samples, using online solid phase extraction (SPE) with liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS), is discussed in Chapter 2. The results of the concentrations of PFCs found using the developed method and correlations between PFC concentrations in plasma and various covariates are discussed in Chapter 2. Conclusions of this study and future directions are discussed in Chapter 3.

1.2. Importance of PFCs

PFCs are used in a variety of household items such as cookware coatings, food packaging, stain repellents, and insecticides (Houde et al., 2006). PFCs pose potential environmental and health problems because they have found to be toxic, persistent, and bioaccumulative (Villagrasa et al., 2006). PFCs consist of a hydrophobic alkyl chain, which is either partially or fully fluorinated, and a hydrophilic functional group. Production of PFCs is desirable as they are chemically stable, have surface tension lowering properties, and can form stable foams (Prevedouros et al., 2006). The structures of PFCs investigated in this project are shown in Table 1.1. PFCs have been referred to as the "PCBs (polychlorinated biphenyls) of the twenty-first century" (Villagrasa et al., 2006) and may be a cause for concern to human health.

Table 1.1. List of PFCs used in this project, their abbreviations, and structures.

Compound	Abbreviation	Structure
Perfluoro-*n*-pentanoic acid	PFPA	
Perfluoro-*n*-hexanoic acid	PFHxA	
Perfluoro-*n*-heptanoic acid	PFHpA	
Perfluoro-*n*-octanoic acid	PFOA	
Perfluoro-*n*-nonanoic acid	PFNA	
Perfluoro-*n*-decanoic acid	PFDA	
Perfluoro-*n*-undecanoic acid	PFUA	
Perfluoro-1-butanesulfonic acid	PFBS	

Compound	Abbreviation	Structure
Perfluoro-1-hexanesulfonic acid	PFHxS	
Perfluoro-1-octanesulfonic acid	PFOS	
Perfluoro-1-decanesulfonic acid	PFDS	
2*H*-perfluoro-2-decanoic acid	8:2 FTUCA	
Perfluoro-1-octanesulfonamide	FOSA	
N-methylperfluoro-1-octanesulfonamide	MeFOSA	
N-ethylperfluoro-1-octanesulfonamide	EtFOSA	
2-(*N*-methylperfluoro-1-octanesulfonamido)-ethanol	MeFOSE	
2-(ethylperfluoro-1-octanesulfoamido)-ethanol	EtFOSE	

PFCs are found in both abiotic and biotic media. PFCs have been found in abiotic media such as sediment, soils, sludge, and surface waters, and in biotic media such as fish, herring gull eggs, seal liver, human blood, and milk (Gosetti et al., 2010). Fluorinated surfactants are stable in the presence of heat, acids and bases, reducing agents, and oxidizing agents (Villagrasa et al., 2006). The energy of the carbon-fluorine bond, which is up to 130 kcal/mol (Lemal, 2004), makes these compounds very stable (Hansen et al., 2001).

Fluorotelomer alcohols (FTOHs), perfluoroalkylsulfonamides (FOSAs), and perfluorooctanesulfonamido-ethanols (FOSEs) are volatile and have potential for long-range transport (De Silva & Mabury, 2006; Shoeib et al., 2006). These compounds have the potential to travel to remote areas of the world and can degrade to PFOS and perfluorocarboxylic acids (PFCAs) (van Leeuwen & de Boer, 2007) which may explain why PFOS and PFCAs are found in these remote areas (Cai et al., 2012). For example, 8:2 FTOH has an estimated atmospheric residence time of 80 days (Piekarz et al., 2007), providing sufficient time for this volatile compound to be transported through the atmosphere. It is also hypothesized that PFCAs are globally transported via ocean currents and aerosols, as well as atmospheric transport of PFCAs in the gas phase (Webster & Ellis, 2010).

Due to environmental persistence, the Canadian government has set usage guidelines for PFOS, which has also been added to the list of Persistent Organic Pollutants by the Stockholm convention (Harada et al., 2010). In 2000, the principal manufacturer of PFOS, the 3M Company, announced that they would stop producing PFOS products, as well as start reducing PFOA emissions (Haug et al., 2009). Since this

phase-out, PFOS concentrations in human blood and arctic wildlife have decreased (Y. Wang et al., 2009). PFCs that have been used to replace PFOS and PFOA have shorter carbon chains (four to seven carbons) (Ahrens et al., 2009; Olsen et al., 2009; Wilhelm et al., 2010) and are thought to be less toxic and less bioaccumulative (Ahrens et al., 2009; Olsen et al., 2009; Wilhelm et al., 2010; Conder et al., 2008). Shorter chain-length PFCs have recently been found in new consumer items (Herzke et al., 2012), demonstrating their presence as replacement PFCs.

In 2006, the United States of America (U.S.) Environmental Protection Agency began an initiative to reduce PFOA and related chemicals in the environment by 95% by 2010, and aimed to eliminate them from the environment by 2015 (U.S. Environmental Protection Agency (EPA), 2012). The European Union has restricted PFOS production, use, and distribution since 2008 (Fromme et al., 2010). The EPA has set limits of 0.2 μg/L for PFOS and 0.4 μg/L for PFOA in drinking water, and the United Kingdom (UK) Health Protection Agency set the limits as 0.3 μg/L for PFOS and 10 μg/L for PFOA (Gosetti et al., 2010). PFOA and longer-chained PFCAs are commonly manufactured as polymer additives, as industry has not yet found a suitable replacement (Martin et al., 2004).

1.3. Physical Properties

Perfluorinated compounds contain carbon atoms where all C-H bonds are replaced with C-F bonds (Thibodeaux et al., 2003), and polyfluorinated compounds contain an alkyl chain that is partially fluorinated (Jahnke & Berger, 2009). Typically, natural organofluorine molecules contain fewer fluorine atoms than man-made

fluorinated molecules (Villagrasa et al., 2006). PFCs contain a hydrophobic fluorinated alkyl chain at one end of the molecule, and a hydrophilic functional group at the other end. PFCAs and 8:2 FTUCA contain carboxylic acids as the functional groups, perfluorosulfonic acids (PFSAs) contain sulfonic acids as the functional group, and FOSEs and FOSAs contain sulfonamides as the functional group. These functional groups can be neutral, positively or negatively charged.

PFCs are ideal surfactants because of their physical properties. Of the various perflurocarbon chain lengths, the eight-carbon PFCs are the best surfactants (Lau et al., 2007), which is why these PFCs were produced in large quantities. PFCs typically have a chain-length of four to fourteen carbons (Mosch et al., 2010). The chain-length affects physical and chemical properties such as elimination half-life, volatility, Henry's law constant, and sorption capacity (S. K. Kim et al., 2011).

The physical properties of PFCs make it difficult to determine partitioning coefficients, vapour pressure, and pK_a values. For many of these, only predicted values can be determined. For example, the vapour pressure of PFOA is very difficult to determine because it is such a stable compound with low volatility; experimentally it could take days to collect a single point of data (Barton et al., 2008). The partitioning of analytes between organic and aqueous solutions can be assessed by the octanol-water partitioning coefficient (K_{ow}). For K_{ow} values, predictive models are not suitable for PFCs because of their unique properties and K_{ow} values may not be appropriate for assessing PFC partitioning (Houde et al., 2006). Surfactants tend to be present at interfaces of different solutions, making measurements difficult. Ionic surfactants will exist in an aqueous phase as ions but will need to become neutral in order to partition to an organic

phase. Therefore, these attempts at predicting the K_{ow} values are flawed (Tolls & Sijm, 1995). Also, the strong carbon-fluorine bonds and intermolecular bonds to functional groups make predicting partitioning coefficients difficult (Thuens et al., 2008). Because of the difficulty of predicting partitioning coefficients for PFCs, conflicting values have been determined and therefore must be evaluated with caution and reproducibility (Rayne & Forest, 2010). The distribution of PFCs and their precursors is dependent on their physical properties. The vapour pressure (P_L), log K_{ow}, log of the air-water partitioning coefficient (K_{aw}), log of the octanol-air partitioning coefficient (K_{oa}), and pK_a of a PFAS, PFAC, FTOH, FOSA, and FOSE are listed in Table 1.2.

Table 1.2. Partitioning constants of five PFCs.

Analyte	P_L (Pa) at 25°C	log K_{ow}	log K_{aw}	log K_{oa}	pK_a
PFOS	0.54[b], 0.000331[c]	5.25[b]	-2.40[b], <2x10^{-6} [c]	7.80[b]	NA
PFOA	4.17[h],0.62[b]*	4.30[b]	-2.37[b]	6.80[b]	-0.1[d], 0.7[d]
8:2 FTOH	227[a], 2[g], 3[g]*, 254[e]	6.14[b]*	1.57[a] (Pa m^3/mol), 0.58[b]	5.48[f]	NA
FOSA	-0.99[b]	4.35[b]	-3.92[b]	8.43[b]	NA
MeFOSE	0.70[a], 0.00200[i],	4.80[b]	-3.08[b]	7.45[b]	NA

NA = not available

a. Lei et al., 2004 (experimentally determined)

b. Arp et al., 2006 (predicted value, * was experimentally determined)

c. 3M Company, 2003 (stated that impurities in the sample were probably the cause of any measured vapour pressure)
d. Goss, 2008 (predicted value)
e. Stock et al., 2004a (predicted value)
f. Goss et al., 2006 (predicted value)
g. Krusic et al., 2005 (predicted value; * was experimentally determined at 21^{o}C)
h. Kaiser et al., 2005 (extrapolated from experimental values)
i. Shoeib et al., 2004 (experimentally determined)

1.3.1. Degradation

PFCAs and PFSAs, such as PFOS and PFOA, do not undergo any known environmental biotic or abiotic transformations (Fromme et al., 2010). Internal studies by 3M showed that PFOS does not undergo photolysis reactions under environmentally relevant conditions (Martin et al., 2010). However, the volatile PFCs can degrade to PFCAs and PFSAs. FTOHs and FOSA are precursors for PFCAs and PFOS, and are converted into these end products through biotic and abiotic modes (van Leeuwen & de Boer, 2007). FTOHs can be metabolized to produce PFOA, and FOSAs and FOSEs can metabolize to PFOS (Vestergren et al., 2008). Laboratory studies have shown that 8:2 FTOH can be metabolized in rats to produce PFOA and PFNA via the intermediates 2-perfluorooctyl ethanoic acid (8:2 FTCA) and 8:2 FTUCA (Figure 1.1) (Butt et al., 2010; Hagen et al., 1981; Martin et al., 2005). The oxidation of FTOHs by cytochrome P450 enzymes is the first step in the pathway for the production of PFCAs, but FTOHs can also be conjugated to form glucuronide or sulfate metabolites (Butt et al., 2010; Fasano et al.,

2006; Martin et al., 2005). In rainbow trout and rat liver microsomes, EtFOSA and EtFOSE can undergo biotransformation processes including deethylation to produce FOSA, which can subsequently be transformed to PFOS (Figure 1.2) (Tomy et al., 2004; Xu et al., 2004). EtFOSE and FOSA can also be conjugated to form glucuronide metabolites in rat liver microsomes (Xu et al., 2004).

Figure 1.1. Biotransformation pathway of FTOHs to produce PFCAs. Reprinted (adapted) with permission from Butt et al., 2010. Copyright (2010) American Chemical Society.

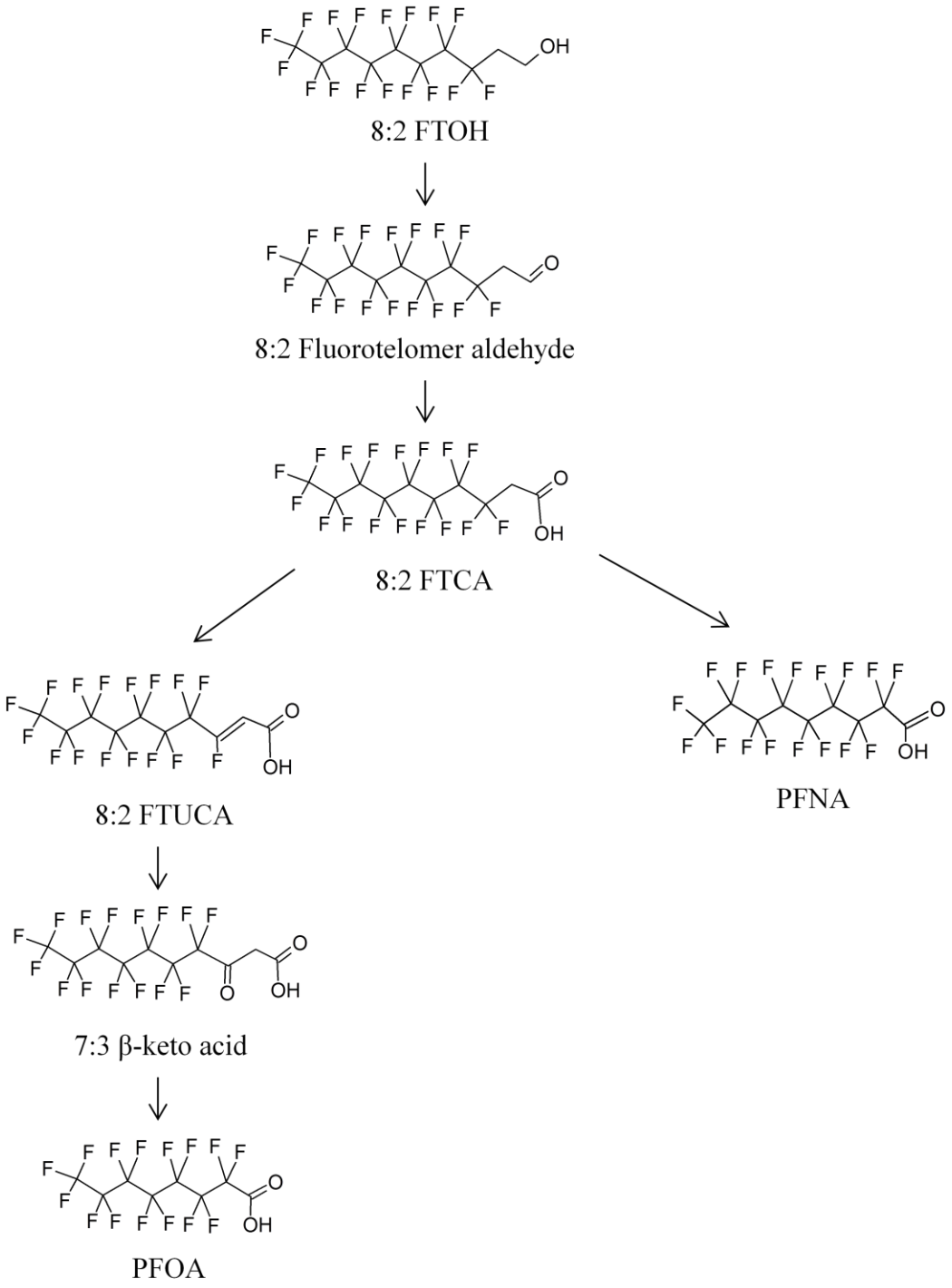
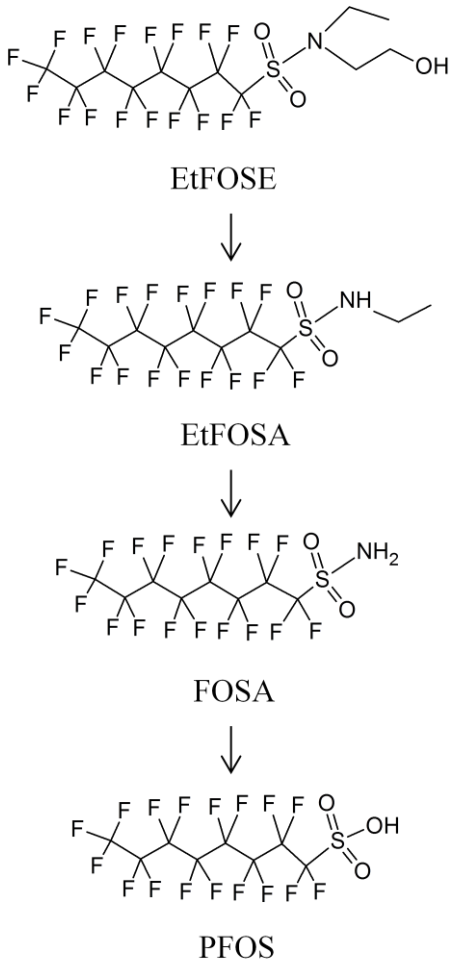


Figure 1.2. Biotransformation pathways of FOSEs and FOSAs to produce PFOS. Reprinted (adapted) with permission from Xu et al., 2004. Copyright (2004) American Chemical Society.



Internal studies by 3M showed that large PFCs could undergo hydrolysis to yield PFOS and PFOS precursors (Martin et al., 2010). For example, NMeFOSE acrylate and NEtFOSE acrylate were subject to hydrolysis in laboratory experiments. It was hypothesized that these compounds were degraded via hydrolysis at the sulfonamide bond to give PFOS, at the alkene to give an alcohol, or at the ester to give NEtFOSE (Martin et al., 2010). Furthermore, NEtFOSE was shown to hydrolyze to PFOS under

temperature and pH conditions that may be relevant in landfills (Martin et al., 2010). Only a few studies have been conducted on the atmospheric oxidation of PFOS precursors. These limited studies have shown that OH radicals would degrade EtFOSA and MeFOSE (Martin et al., 2010).

1.4. Production

PFCs have been produced via the electrochemical fluorination process since 1947 (Prevedouros et al., 2006). 3M, the world's major producer of PFCs, declared that they would end the electrochemical fluorination process by 2002 (de Voogt & Saez, 2006; Prevedouros et al., 2006). Production continued in Europe and China even after the phase-out of PFOS and other PFCs between 2000 and 2002, and production in China is still ongoing (Martin et al., 2010; L. Zhang et al., 2012).

The electrochemical fluorination process converts hydrocarbon alkylsulfonyl halides and alkylcarbonyl halides to perfluorinated acid halides using anhydrous hydrogen fluoride and an electric current (De Silva & Mabury, 2006). This process replaces the C-H bonds from the alkyl chains to C-F bonds, and breakage of C-C bonds and molecular rearrangements produce both linear and branched isomers (Karrman et al., 2007a). PFCs produced by electrochemical fluorination contain approximately 70-90% linear isomers (Karrman et al., 2007a). PFHxS can be formed as a contaminant in PFOS-based products manufactured by this process (Karrman et al., 2006).

Reaction of PFOS via electrochemical fluorination:

$$2C_8H_{17}SO_2F + 34HF \xrightarrow{4.5 \text{ to } 7.0 \text{ V}} 2C_8F_{17}SO_2F + 17H_2$$ (3M Company, 1999b)

The production from telomerization has increased since the end of the electrochemical fluorination production (de Voogt & Saez, 2006). The telomerization process produces a telomer from tetrafluoroethene and a perfluoroalkyl iodide. In industry, the polymerization reaction is quenched by insertion of ethylene, which forms the precursor compound of FTOHs, fluorotelomer olefins, and fluorinated acids (De Silva & Mabury, 2006; Hekster et al., 2003). Compounds produced by telomerization contain a linear alkyl chain and an even number of carbon atoms (de Voogt & Saez, 2006). Similarly, oligomerization of perfluoroolefins or perfluoroolefin oxides yields purely linear chains, whereas electrochemical fluorination yields uncharacterized technical mixtures of branched and linear isomers (Benskin et al., 2007).

Example reaction of telomerization:

1. $5C_2H_4 + IF_5 + 2I_2 \xrightarrow{catalyst} 5C_2F_5I$
2. $C_2F_5I + nC_2F_4 \longrightarrow C_2F_5(C_2F_4)_nI$
3. $C_2F_5(C_2F_4)_nI + C_2H_4 \longrightarrow C_2F_5(C_2F_4)_nC_2H_4I$ (Hekster et al., 2003)

From 1951 to 2004, it is estimated that 3200-7300 tonnes of PFCAs were emitted from industry through direct and indirect sources combined (Prevedouros et al., 2006). It is estimated that in 2000, approximately 3500 metric tons of PFOS and 500 metric tons of PFOA were produced globally (Gosetti et al., 2010). The Organisation for Economic Co-

operation and Development estimates the historic production of PFOS and similar compounds to be 4500 tonnes a year (van Leeuwen & de Boer, 2007). In recent years in China, the output of PFOS was estimated at 100 tonnes per year, with the majority of production allotted to metal plating, aqueous fire-fighting foams, and pesticides (L. Zhang et al., 2012).

1.5. Commercial Applications and Uses

PFCs have been used as fabric, upholstery, carpet, and leather protectors, in paper and packaging, carpet spot cleaners, and fire extinguisher foam concentrates (3M Company, 1999b). Since the phase-out of PFOS production, carpet protection products have been fluorotelomer based (Trudel et al., 2008). Short-chained PFSAs like PFBS are used in the same manner as PFOS was (i.e. as protectors for fabric, carpet, and upholstery) (Olsen et al., 2009). Perfluorooctanoate, the anion of PFOA, is produced as a byproduct of the telomerization process, and therefore, may be present in treated items such as carpets (Washburn et al., 2005). Additionally, PFOA is used as an emulsifier in the production of fluoropolymers and fluoroelastomers such as polytetrafluoroethylene (PTFE) (Lau et al., 2007). MeFOSE has been found in home carpet stain repellent products such as Scotchgard® (Dinglasan-Panlilio & Mabury, 2006). EtFOSE has been used for production of paper protection products, such as food packaging (Stock et al., 2004b). FTOHs are manufactured as intermediates in the production of adhesives, inks, polymers, waxes and polishes, inks, and paints (Stock et al., 2004b). Residual non-bound products such as FOSEs and FOSAs have been produced at 1-2% or lower of the total concentration of PFCs, and if not bound to a polymer, these have potential to be released

into the environment (3M Company, 1999a; Stock et al., 2004b). FOSAs have been manufactured for decades as surfactants or as polymer components (Y. Wang et al., 2009).

1.6. Analytical Methods of Analyzing PFCs in Blood

Although PFCs have been in use for decades, it has only been with recent technology that they have been measured in the environment. It was not until the arrival of liquid chromatography coupled with mass spectrometry (LC-MS) with electrospray ionization (ESI) that PFC concentrations and identities could be accurately determined (Reagen et al., 2008). The first analysis of PFCs in human serum was done by nuclear magnetic resonance (NMR) in the 1960s, and in the 1980s, PFCs were first analyzed by gas chromatography (GC) with flame ionization, electron capture detection, and MS (Karrman et al., 2005). ^{19}F NMR can be used to analyze PFCs, but it may incorrectly quantify analytes and is not suitable for determining branched isomers (de Voogt & Saez, 2006). ^{19}F NMR is not ideal for analysis of PFCs in human blood because of the low concentration of PFCs in environmental matrices, lack of chromatographic separation of complex mixtures, and extensive sample preparation needed. Recently, the most common methods used are high pressure liquid chromatography (HPLC) with mass spectrometry (Benskin et al., 2007). LC-MS with single-quadrupole technology requires more sample clean-up to remove interferences before analysis than LC-MS/MS with triple-quadrupole technology (de Voogt & Saez, 2006). LC-MS/MS is more selective than LC-MS as it monitors the transition of parent to daughter ions. Environmental samples are complex matrices and can contain interfering analytes of the same mass as target analytes; using

LC-MS/MS adds the extra sensitivity to avoid reporting interferences as target analytes (Villagrasa et al., 2006).

GC with mass spectrometry (GC-MS) methods offer parts per billion detection limits, but LC-MS and LC-MS/MS can offer parts per trillion detection limits (Gosetti et al., 2010). Derivatization techniques with GC analysis have been investigated. However, compounds such as PFOS leave unstable derivatives due to the perfluoroalkyl sulfonic leaving group, making this technique of limited value for analysis of PFCs (Holm et al., 2004). For example, the addition of tetrabutylammonium hydroxide has been used as a derivatization technique for determining PFOS isomers (Chu & Letcher, 2009). GC has advantages over LC in that it has greater resolving power and avoids contamination associated with LC (De Silva & Mabury, 2006).

Using ultraviolet detection with LC has low sensitivity because most perfluoro surfactants do not contain suitable chromophores (Holm et al., 2004). However, this method is less prone to matrix effects than ESI (Martin et al., 2004). Ion trap mass-analyzers can be used with MS/MS analysis for the detection of PFCAs but not PFSAs. For example, this method is not suitable for PFOS because of the large mass difference between the parent ion (mass-to-charge ratio (*m/z*) 499) and the product ion (*m/z* 99) (Martin et al., 2004). Quadrupole/time-of-flight mass analyzers have lower sensitivity and linear range than triple-quadrupole MS systems, and therefore, are not often used (Martin et al., 2004). It has been demonstrated experimentally that ESI sources provide better sensitivity than atmospheric pressure chemical ionization for detecting PFCs due to ionizable carboxylic acid and sulfonic acid functional groups (Gosetti et al., 2010).

Labeled PFC standards have not been readily available until recently. Matrix effects such as ion-suppression and ion-enhancement can be examined with these standards (Reagen et al., 2008). Before the availability of labeled standards, tetrahydroperfluorooctanesulfonate was often used (Reagen et al., 2008), although some brands of PTFE septa for vial seals released a contaminant that interfered with the tetrahydroperfluorooctanesulfonate peak (Karrman et al., 2005). This peak is an interference because PFOA is used in the manufacturing of PTFE (Fromme et al., 2010). However, labeled standards for many PFCs are now available, which decrease the chance of error in identifying the analyte.

Due to their surfactant properties, certain PFCs can adsorb to surfaces. Experimental investigations have found that PFOS concentrations were reduced by 25% when stored in glass vials, but not reduced when stored in polypropylene vials (Holm et al., 2004). Therefore, it is best to store PFC standards and samples in non-glass containers such as polypropylene. Samples should be refrigerated or frozen to prevent degradation such as FTOHs to PFCAs and degradation of FOSAs to PFOS (Martin et al., 2004). PFCAs are used as polymerization aids in the manufacturing of fluoropolymers such as Teflon®, and thus, these polymers must be avoided in analytical methods (Martin et al., 2004). These fluoropolymers are frequently found in vial caps and septa, as well as internal components of HPLC systems (Martin et al., 2004). PFCs have also been found in laboratory reagents such as methanol, and so reagent blanks must be analyzed carefully. Replacing fluoropolymer components with stainless steel, polyetheretherketone, or polypropylene solves this problem, as does installing a column up-stream of any fluoropolymer parts in HPLC systems (Martin et al., 2004). Flushing

the HPLC system with solvents before analysis also aids in avoiding contamination of residual PFCs from the system.

Because blood is such a complex matrix, pre-treatment is often required before analysis can be performed. In blood, trichloroacetic acid, formic acid, or acetonitrile is typically added in order to precipitate red blood cells (van Leeuwen & de Boer, 2007) and dissociate PFCs from proteins in blood, as PFCs bind to plasma proteins (Karrman et al., 2005). This pre-treatment helps prevents the SPE column from becoming clogged (van Leeuwen & de Boer, 2007). The precipitate can be separated by centrifugation, and then the supernatant is collected for analysis. Protein precipitation by organic solvents such as acetonitrile has been found to be highly effective for dissociating and recovering PFCs from blood proteins (Reagen et al., 2008).

Many previous studies have used an off-line extraction clean-up procedures, where the fluoroorganic compounds were extracted into an organic solvent such as methyl-*tert*-butyl ether, the solvent evaporated, then re-dissolved in an injection solvent (Holm et al., 2004). These off-line methods are time consuming, increase the chance of contamination, and risk losing analyte due to adsorption or evaporation. An improved method of analyzing PFCs can be achieved using online SPE. With online SPE, the SPE step is automated into an LC-MS system, eliminating the time consuming step of preparing samples with off-line SPE.

1.7. PFCs in the Human Body

Legacy persistent organic pollutants such as polychlorinated biphenyls and dichlorodiphenyltrichloroethane bioaccumulate in adipose tissue, but PFCs accumulate in

the liver because they bind to blood proteins (Haug et al., 2009), especially albumin (Bischel et al., 2011; Y. Chen & Guo, 2009; Karrman et al., 2006; Li et al., 2010; MacManus-Spencer et al., 2010).

PFCs levels in humans are most often determined by analyzing blood, as the nature of PFC compounds leads them to be found mostly in blood, liver, and kidneys (Vassiliadou et al., 2010). However, there is no standardized manner of reporting PFCs in blood. They have been reported as whole blood, plasma, or serum concentrations. Analysis of whole blood has been compared to serum levels by multiplying whole blood values by two (Kannan et al., 2004; S. K. Kim et al., 2011). This assumes that there is a one to one volumetric ratio between plasma and serum. Red blood cells account for 45% of total blood volume in men and 42% in women (Karrman et al., 2006). Therefore, plasma should account for 55-58% of total blood volume (Karrman et al., 2006). Similar to serum levels, in theory, plasma concentrations should be divided by 1.8 for men and 1.7 for women to compare to whole blood concentrations (Karrman et al., 2006). However, one study found this multiplication factor to be lower than expected when concentrations of whole blood and plasma were compared in both men and women (Karrman et al., 2006). In order to minimize error, determined concentrations of PFCs in plasma or serum should be reported as they are found, and not estimated as whole blood concentrations.

Scenario-based risk assessments have investigated the possible sources of PFOS and PFOA to humans from precursors. For the majority of scenarios over varying ages, diet appeared to be the main exposure route (Bjorklund et al., 2009; Egeghy & Lorber, 2011; Trudel et al., 2008; Vestergren et al., 2008). Other exposure routes include

inhalation of indoor air and dust, ingestion of dust, and hand-to-mouth contact with consumer products such as carpets and clothing (Bjorklund et al., 2009; Egeghy & Lorber, 2011; Trudel et al., 2008; Vestergren et al., 2008).

From the limited data available, it appears that precursor compounds to PFOS and PFOA have a limited contribution to total exposure (Fromme et al., 2009; Vestergren et al., 2008). It has been estimated that 5% of FTOHs and 20% of FOSAs and FOSEs convert to PFOS and PFOA in humans, and therefore, the total contribution towards degradation products of precursors such as these will be minimal (Fromme et al., 2009). Levels of these precursor compounds found in human serum and blood are typically low, so the contribution towards PFOS and PFOA exposure is expected to be low.

1.7.1. PFC Concentrations in Canadian Blood Samples

PFCs have been found in blood from Canadians all over the country. Serum samples from participants over the age of 20 years in Ottawa, Ontario, and Gatineau, Quebec were collected before 2002 and found to contain an average of 28.8 ng/mL for PFOS, and 3.4 ng/mL for PFOA (Kubwabo et al., 2004). In the Nunavik region of Northern Quebec, PFOS plasma levels were found at an average of 28.2 ng/mL for men and 23.1 ng/mL for women for 18-74 year olds sampled in 2004 (Chateau-Degat et al., 2010). Plasma samples taken from approximately 5600 Canadians aged 6-79 years old between 2007-2009 showed geometric means of 11.1 and 7.1 ng/mL for PFOS and 2.9 and 2.2 ng/mL for PFOA for males and females, respectively (Haines & Murray, 2012). Serum samples from pregnant women in British Columbia (Beesoon et al., 2011), Alberta (Chan et al., 2011; Hamm et al., 2010), and Ontario (Monroy et al., 2008) were found to

have average PFOS concentrations of 5.5, 9.0, 7.4 and 18.3 ng/mL and average PFOA concentrations of 1.8, 2.1, 1.4 and 2.5 ng/mL, respectively. It should be noted that the two studies from Alberta used subsamples from the same sample set.

Blood plasma sampled from children (11-54 months old) from Nunavik in Northern Quebec in 2006-2008 showed geometric means of 3.4 ng/mL of PFOS and 1.6 ng/mL of PFOA (O'Brien et al., 2012). Umbilical cord serum samples from British Columbia (Beesoon et al., 2011) and Ontario (Monroy et al., 2008) were found to contain an average PFOS concentration of 1.8 and 7.2 ng/mL and average PFOA concentration of 1.1 and 1.9 ng/mL, respectively (Table 1.3). The concentrations found in Canadian studies are similar to what has been found in the U.S. during the timeframe samples were collected (Olsen et al., 2012). More detailed comparisons of maternal blood and cord blood concentrations from Canada and around the world are discussed in Chapter 2.

1.7.2. Localization and Elimination in the Human Body

PFOS and PFOA have been found in human lungs, kidneys, liver, blood, thyroid, brain, and other tissues in post-mortem samples that were non-occupationally exposed (Maestri et al., 2006; Olsen et al., 2003). In pooled samples from seven subjects, lungs contained the highest concentration of PFOA, while liver contained the highest concentration of PFOS (Maestri et al., 2006). Individual samples from 23 subjects showed an average PFOS liver to serum ratio of 1.3:1, which may be an important factor when investigating toxicity (Olsen et al., 2003).

Human tissues that can be readily sampled include blood, urine, breast milk, fingernails and toenails. In samples from individuals undergoing surgery, both PFOS and

PFOA were detected in bile and cerebral spinal fluid (Harada et al., 2007). In human fingernails and toenails, PFOS, PFNA, PFOA, PFDA, PFDoA, and PFTA have been detected (W. Liu et al., 2011). PFOS and PFOA have been detected in human urine (Harada et al., 2005), and PFHxS has been measured in sweat (Genuis et al., 2010). In human breast milk, PFOS, PFOA, PFDA, PFUA and FOSA have been detected (Karrman et al., 2007b; J. Liu et al., 2011). Many PFCs have been measured in human blood including PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUA, PFBS, PFHxS, PFOS, and FOSA (Haug et al., 2009; Lien et al., 2011).

Human and animal studies have shown renal (Harada et al., 2005) and hepatic excretion (Genuis et al., 2010) as elimination routes for PFCs. Animal studies have shown that PFOS and PFOA are poorly eliminated from the body and after oral absorption may re-enter the gastrointestinal tract via enterohepatic circulation (Lau et al., 2007). The combination of high protein binding affinity and repeated circulation of PFCs to the liver and kidneys through the path to elimination then uptake leads to long residence times in humans (Genuis et al., 2010). It has been determined that when PFOS binds to human albumin, it forms a complex with a different conformation than free human albumin or other fatty-acid bound albumin complexes, which may explain why PFOS has a long residency time in the body (Luo et al., 2012). This is indicated by the long half-lives of PFOS and PFOA, which are on the order of years in humans (Burris, 2002; Olsen et al., 2007). Additionally, it has been shown *in vitro* that when PFOS was bound to albumin the transport function of the albumin was reduced (X. Zhang et al., 2009), which may limit the availability of PFOS for elimination.

Some studies have shown that in general, serum concentrations of PFOS and PFOA in humans are higher in males than in females (Haines & Murray, 2012; Harada et al., 2004). In the U.S., it has been observed that PFOS, PFOA, PFHxS, and PFNA were significantly higher in males than females (Kato et al., 2011; Lau et al., 2007). Additionally, it has been shown that serum concentrations are higher in post-menopausal women than in pre-menopausal women (Harada et al., 2005) and women who were not pregnant than in pregnant women (Woodruff et al., 2011). This indicates that there may be loss of PFOS and PFOA through menstrual bleeding as well as maternal transfer.

The serum elimination half-life in humans has been studied for retired production workers of PFCs, and shown to be 4.4 for PFOA and 8.7 years for PFOS (Burris, 2002). The half-lives in human serum have also been reported as 5.4 years for PFOS, 3.8 years for PFOA, and 8.5 years for PFHxS (Olsen et al., 2007). Half-lives from infant blood spots (whole blood spotted on filter paper) were estimated at 4.4 years for PFOS, 4.1 years for PFOA, and 8.2 years for PFHxS (Spliethoff et al., 2008).

1.8. Exposure

Exposure in infants differs from exposure in adults because infants have both pre-natal and postnatal exposure. The different sources of exposure of PFOS and PFOA to infants and the importance of each source are outlined in the following discussion.

1.8.1. Prenatal Exposure

Humans can be exposed to PFCs even before birth, as there is placental transfer from the mother to the fetus (Vassiliadou et al., 2010). Laboratory studies have shown

that developmental endpoints are more strongly affected by exposure *in utero* than by lactation exposure (Butenhoff et al., 2009). For example, a cross-foster study determined that exposure to PFOA from lactation alone was not a significant determining factor for postnatal survival, eye opening or weight gain (Abbott et al., 2007).

A practical way to measure PFC exposure in the fetus is by measuring concentrations in the umbilical cord blood at the time of birth. The presence of PFCs in cord blood indicates that there has been transfer from the mother to the fetus. For example, PFOS and PFOA were both found in 100% of 105 samples in a Canadian study (Monroy et al., 2008). Also, PFOA was found in 100% of umbilical cord samples from a study in the U.S. and PFOS was found in 99% of samples (Apelberg et al., 2007a). Similarly, in a representative sample, 99% of pregnant women in the U.S. were found to contain PFCs in their blood (Woodruff et al., 2011).

It is typically found that cord blood contains the highest levels of PFOS and PFOA compared to other PFCs (Apelberg et al., 2007a; Monroy et al., 2008; S. K. Kim et al., 2011). Table 1.3 displays measured concentrations of PFCs in cord blood from various countries, which demonstrates placental transfer of PFCs from mother directly to newborn.

Table 1.3. Mean or median concentrations (ng/mL) of PFCs in cord blood from various countries.

Country, Sampling Year(s)	Plasma, Serum, or Whole Blood; Median or Mean	Analyte					
		PFOA	PFNA	PFDA	PFUA	PFHxS	PFOS
Denmark, NA[a]	Serum, mean	3.1	0.37	0.34	-	9.1	6.6
Germany, 2003[b]	Plasma, mean	3.4	-	-	-	-	7.2
Japan, 2003[c]	Serum, mean	<0.5	-	-	-	-	2.9
U.S., 2003-2004[d]	Whole blood, mean	0.73	0.38	-	-	1.64	1.74
Taiwan, 2004-2005[e]	Plasma, mean	4.42	10.5	1.98	22.4	0.45	7.65
Canada, 2004-2005[f]	Serum, mean	1.94	0.94	-	-	5.05	7.19
U.S., 2004-2005[g]	Serum, geometric mean	1.6	-	-	-	-	4.9
South Africa, 2005-2006[h]	Serum, median	1.3	0.2	-	-	0.3	0.7
Korea, 2007[i]	Serum, mean	1.1	0.37	0.12	0.46	0.58	2.0
Australia, 2006-2007[j]	Serum, mean	1.6	-	-	-	-	10.1
Norway, 2007-2008[k]	Plasma, median	0.88	0.12	0.04	0.04	0.20	1.52

Country, Sampling Year(s)	Plasma, Serum, or Whole Blood; Median or Mean	Analyte					
		PFOA	PFNA	PFDA	PFUA	PFHxS	PFOS
Canada, 2007-2008[l]	Serum, mean	1.1	0.4	0.1	-	0.7	1.8
Germany, 2007-2009[m]	Plasma, mean	1.7	0.4	<0.4	-	0.3	1.1
Korea, 2008-2009[n]	Serum, median	1.15	0.45	0.19	-	0.34	1.26
China, 2009[o]	Serum, mean	1.50	0.33	0.24	0.30	0.06	1.69

Values of "-" were not analyzed. Values with "<" were below the detection limit of the analysis.

a. Needham et al., 2011

b. Midasch et al., 2007

c. Inoue et al., 2004

d. Spliethoff et al., 2008

e. Lien et al., 2011

f. Monroy et al., 2008

g. Apelberg et al., 2007b

h. Hanssen et al., 2010

i. S. K. Kim et al., 2011

j. Toms et al., 2009

k. Gutzkow et al., 2012

l. Beesoon et al., 2011

m. Fromme et al., 2010

n. S. Kim et al., 2011

o. J. Liu et al., 2011

Concentrations of PFOS are generally lower in cord blood than in maternal serum (Fromme et al., 2010; Midasch et al., 2007). However, concentrations of PFOA have been measured at similar levels in cord blood as maternal serum (Midasch et al., 2007), indicating there may be preferential transfer of PFOA to cord blood over PFOS.

Human serum albumin contains hydrophobic groups and hydrophilic polar groups (Salvalaglio et al., 2010). Human serum albumin is therefore able to bind chemicals with hydrophobic and hydrophilic groups, such as PFCs. PFOA (Wu et al., 2009) and PFOS (Luo et al., 2012; X. Zhang et al., 2009) have both been shown to bind to albumin. The levels of albumin in pregnant women are lower (mean 29 mg/mL) than in women who are not pregnant (mean 43 mg/mL) (Nanovskaya et al., 2006). This decrease in albumin levels in pregnant women will most likely affect the levels of PFCs that are bound to the proteins. *In vitro* studies have shown that PFOS has a higher binding affinity to albumin than does PFOA (Y. Chen & Guo, 2009; Salvalaglio et al., 2010). Perhaps the lower amount of albumin in pregnant women causes more PFOA to exist unbound and therefore, more easily available for transport across the placenta.

In humans, there is very little transfer of albumin across the placenta (Lambot et al., 2006). Therefore, PFCs must cross the placenta in the unbound form. Although the exact mechanism of how PFCs cross the placenta is unclear, fatty acids can cross the human placenta (Hendrickse et al., 1985) and perhaps PFCs cross freely as well due to their similarity in structure to fatty acids.

High correlations between maternal levels of PFCs and umbilical cord samples have been found in studies from Canada (Monroy et al., 2008), Japan (Inoue et al., 2004),

South Africa (Hanssen et al., 2010), Germany (Fromme et al., 2010), Norway (Gutzkow et al., 2012), and China (J. Liu et al., 2011). Therefore, the levels of PFOS, PFOA, and other PFCs that will be present in an infant at the time of birth may be predicted from maternal blood composition. This may be important in predicting potential effects of PFCs to the infant.

1.8.2. Human Breast Milk

It is widely held that breastfeeding may be beneficial to infants by reducing the risk of necrotizing entercolitis, gastroenteritis, respiratory infections and immunologically based diseases, as well as improving cognitive function (Nassar et al., 2011). The World Health Organization suggests that infants should be fed breast milk exclusively for the first six months of age (Nassar et al., 2011).

Newborns are especially sensitive to chemical exposure, and their main exposure is through breast milk. PFCs are present in human milk, but are not as abundant as in human blood as PFCs preferentially bind to serum proteins over milk proteins (Roosens et al., 2010). However, the mechanism by which PFCs move from blood to breast milk is unclear. PFCs concentrations in human milk have been found to be approximately one percent of those in human serum (Fromme et al., 2010). The lower concentration in human milk could be due to the lower level of protein in milk compared to blood. Human milk contains 9-11 g/L of protein, where plasma contains 35-50 g/L of protein. The proteins found in human milk are predominately lactalbumin and casein, whereas the protein in blood is albumin (Volkel et al., 2008).

Values of breast milk concentrations of PFCs from various countries are displayed in Table 1.4. One study concluded that approximately 300 ng of total PFCs per day could be transferred to an infant from breast milk (Llorca et al., 2010). Direct transfer of PFCs from mother to infant is further indicated from the observed significant correlation between PFOS concentrations in breast milk and infant serum at six months of age (Fromme et al., 2010). Transfer efficiencies of PFCs in milk can be determined by the ratio of maternal blood to milk concentrations. In Korea, the transfer efficiencies of milk were determined as 0.011 for PFOS, 0.025 for PFOA, and 0.008 for PFHxS (S. K. Kim et al., 2011).

Table 1.4. Concentrations of PFOS and PFOA in human breast milk (ng/L) for various countries.

Country	PFOS			PFOA		
	Range	Median	Mean	Range	Median	Mean
Cambodia[a]	17.2-327	39.9	67.3	<42.5-132	NA	NA
China[b]	45-360	100	NA	47-210	110	NA
China[c]	9-198	56	42	25-144	181	121
China[d]	NA	NA	NA	0-122	51	51.6
Germany[e]	<30-110	40	NA	<15-250	NA	NA
Germany[f]	28.0-239	113	116	NA	NA	NA
Hungary[f]	96-639	330	317	NA	NA	NA
India[a]	<11.0-120	39.4	46.1	<42.5-335	NA	NA
Indonesia[a]	25.4-256	67.2	83.6	<42.5	NA	NA
Japan[a]	140-523	196	232	<42.5-170	67.3	77.7
Japan[d]	NA	NA	NA	<40-194	89	93.5
Korea[g]	32-130	NA	61	<43-77	NA	41
Korea[h]	NA	60	NA	NA	50	NA
Korea[d]	NA	NA	NA	<40-173	62	64.5
Malaysia[a]	48.7-350	111	121	<42.5-90.4	NA	NA
Philippines[a]	27.0-208	104	97.7	<42.5-183	NA	NA
Spain[i]	<11.7-865	NA	NA	<15.2-907	NA	NA
Sweden[j]	60-470	166	201	<209-492	NA	NA

Country	PFOS			PFOA		
	Range	Median	Mean	Range	Median	Mean
U.S.[k]	<32.0-617	106	131	<30.1-161	36.1	43.8
Vietnam[a]	16.9-393	58.5	75.8	<42.5-89.2	NA	NA

NA = not applicable (not calculated due to values under the limit of quantification (LOQ) or not given)

a. Tao et al., 2008a

b. So et al., 2006

c. J. Liu et al., 2011

d. Fujii et al., 2012

e. Fromme et al., 2010

f. Volkel et al., 2008

g. S. K. Kim et al., 2011

h. S. Kim et al., 2011

i. Llorca et al., 2010

j. Karrman et al., 2007b

k. Tao et al., 2008b

It can be evaluated whether exposure from breast milk exceeds the set tolerable daily intake (TDI) values from the concentrations given in Table 1.4. TDI values for various organizations and/or countries are displayed in Table 1.5. It is estimated that infants one to six months of age intake an average of 742 mL of breast milk per day (U.S. Environmental Protection Agency (EPA), 2002). If an infant of six months of age is considered with a body weight (bw) of eight kilograms (Llorca et al., 2010), the daily intake values from the means range from 4.3 ng/kg bw/day (India) to 29 ng/kg bw/day (Hungary) for PFOS. For PFOA, the range for daily intake values is 4.1 ng/kg bw/day (U.S.) to 7.2 ng/kg bw/day (Japan).

Table 1.5. Tolerable daily intake values (ng/kg bw/day) of PFOS and PFOA defined by various organizations/countries.

Country or Organization	PFOS TDI	PFOA TDI
European Food Safety Authority[1]	150	1500
Germany[2]	100	NA
UK[3]	300	3000
U.S.[4]	25	NA

1. European Food Safety Authority, 2008
2. BfR, 2006
3. Committee on Toxicity, 2006a; 2006b
4. Tao et al., 2008b

The TDI value from the U.S. (25 ng/kg bw/day) is much lower than TDI values defined by other countries. From the measured concentrations discussed here, the highest

mean value of PFOS from Hungary exceeded the TDI from the U.S. This indicated there might be a risk of developmental effects associated with intake of PFOS from breast milk if the TDI exceeds 25 ng/kg bw/day as it did in samples from Hungary. When the TDI from the U.S. was not considered, only the highest value from the Spanish study exceeds the TDIs. No measured value of PFOA exceeded any of the TDIs. This indicates that in general, TDI values are not exceeded by exposure to PFCs through breast milk.

1.8.3. Infant Formula

An alternative form of food source to infants is infant formula, and therefore, this is another possible source of dietary exposure of PFCs. PFCs could enter infant formula by transfer from packaging and containers during production and storage (Llorca et al., 2010). One study conducted in Germany found no significant differences between concentrations of PFOS and PFOA in infants who had been exclusively breast-fed or exclusively formula-fed (Fromme et al., 2010). However, it was noted that there was a low number of infants who were exclusively formula-fed, so further assessment is warranted. In earlier work, Fromme and coworkers had also found that Hungarian newborns that were exclusively formula-fed had significantly lower blood concentrations of PFOS than newborns that were exclusively breast-fed, but no significant difference was observed with PFOA (Fromme et al., 2009).

There is limited research done on levels of PFCs present in commercially available infant formulas. One study was conducted in the U.S. and evaluated levels of PFCs in infant formula. No measurable concentrations of PFOS (limit of detection 11.0 ng/L) or PFOA (limit of detection 43.8 ng/L) were found, except for in one sample where

PFOS was measured slightly over the detection limit (11.3 ng/L) (Tao et al., 2008b). Similarly, a study from Germany analyzed four infant formulas and found no detectable levels of PFOS or PFOA (LOQ for PFOS was 10 ng/L and 50 ng/L for PFOA) (Fromme et al., 2010).

Conversely, a study in Spain found quite high levels of PFCs in commercially available infant formula. The concentration of PFOS in powdered infant formula ranged from 229 ng/kg to 1100 ng/kg and the concentration of PFOA ranged from 374 ng/kg to 723 ng/kg (Llorca et al., 2010). Therefore, infant formula may be another potential source of PFCs to infants.

The maximum daily limit of PFOS from infant formula from the U.S. was determined to be ≤1.4 ng/kg bw/day (Tao et al., 2008b). This value is much lower than any of the defined TDIs (Table 1.5). Therefore, according to the study from the U.S., exposure to PFOS via breast milk may put infants at a higher risk of toxicity from PFOS and PFOA than exposure through infant formula. The results from the Spanish study are different, however. For an average six-month-old infant consuming 150 g of infant formula per day (Llorca et al., 2010), the range of PFOS consumed corresponds to a range of 4.29 ng/kg bw/day to 20.6 ng/kg bw/day for PFOS. For PFOA, the range is 7.01 ng/kg bw/day to 13.6 ng/kg bw/day. The results from that study indicate that exposure of PFOS and PFOA from breast milk is comparable to exposure from infant formula in Spain (Llorca et al., 2010). None of the calculated values of exposure to PFOS or PFOA exceed TDIs defined by various countries.

1.8.4. Household Air and Dust

PFCs have been detected in indoor air, house dust, water, and consumer products (Apelberg et al., 2007a), so it is expected that PFCs will enter the body through everyday contact in the home via ingestion, inhalation, and/or dermal contact of household dust. People spend over 90% of their time indoors, so exposure through indoor air and dust is expected to contribute to levels of PFCs (Shoeib et al., 2011). Children are susceptible to indoor exposure to PFCs due to the large proportion of their time spent indoors (Osborne et al., 2006). Indoor air contains significantly higher levels of PFCs than outdoor air (Harrad et al., 2010), where indoor air has been found to contain one to two orders of magnitude higher concentrations of PFCs than outdoor air (Shoeib et al., 2011).

Hand-to-mouth contact with carpets is considered a major pathway of PFOS and PFOA exposure for children and infants (Harrad et al., 2010). Prior to the phase-out of production of PFOS, commercially available carpet protection products were based on PFOS chemistry. Due to this, carpet protection products were expected to contain PFOS and its precursor compounds. Since the phase-out of PFOS production, carpet protection products are fluorotelomer-based (Trudel et al., 2008). Perfluorooctanoate, the anion of PFOA, is produced as a byproduct of the telomerization process, and therefore, may be present in treated items such as carpets (Washburn et al., 2005).

Dust samples collected by vacuum in homes in Vancouver, Canada were found to contain a mean of 280 ng/g of PFOS and a mean of 97 ng/g of PFOA. PFOS and PFOA were the most abundant PFCs found in house dust; both compounds were found in 100% of samples (Shoeib et al., 2011). In Ottawa, Canada, house dust from homes was found to contain a mean of 444 ng/g of PFOS and 106 ng/g of PFOA. In this study, PFOS was

only detected in 67% of house dust samples (detection limit 4.56 ng/g) and PFOA detected in 63% of samples (detection limit 2.29 ng/g) (Kubwabo et al., 2005). In both of these Canadian studies, concentrations of PFOS and PFOA were both found to be significantly correlated, indicating that both compounds originate from the same sources (Kubwabo et al., 2005; Shoeib et al., 2011). PFOS and PFOA have also been detected in dust samples from homes in Australia, France, Germany, Kazahkstan, Thailand, the UK, the U.S. (Goosey & Harrad, 2011), Sweden (Bjorklund et al., 2009), China (T. Zhang et al., 2010), and Japan (Moriwaki et al., 2003).

Only one study thus far in North America has analyzed indoor air for PFOS and PFOA. This study determined that air in 39 homes contained a mean PFOA concentration of 113 pg/m^3, and geometric mean of 28 pg/m^3, but PFOS levels were below the detection limit of 0.02 pg/m^3 (Shoeib et al., 2011). The presence of PFCs in both household air and dust warrants their concern as exposure routes for humans.

1.9. Toxicity

PFOS and PFOA have been observed in laboratory animals to cause hepatotoxicity, reduction of cholesterol, reduction of thyroid hormones, and PFOA has also caused tumorgenicity (Abbott et al., 2007; Lau et al., 2004). Because of concern of toxicity of these compounds, their persistence, and presence in human blood, developmental toxicity has been investigated as developing humans are more susceptible to toxins than humans who have outgrown their developmental stages.

Similar to humans, PFOS has been found to transfer from mother to fetus in Sprague-Dawley rats (Monroy et al., 2008), and PFOA has been shown to cross the

placenta of rats (Midasch et al., 2007). Therefore, rats make potential surrogates for human toxicity testing of developmental effects of PFCs. Rodents are typically used in toxicity testing for PFCs. Studies which aim to correlate adverse effects directly to humans, as opposed to animals, are crucial. It should be noted that most toxicity studies use concentrations of PFCs that are not environmentally relevant and are often higher than those for occupationally exposed humans (Burris, 2002). This section on toxicity will focus on the two most prominent PFCs: PFOS and PFOA.

1.9.1. Brain Development

The developing brain of an infant is naturally more vulnerable than an adult brain, including a higher susceptibility to injury from toxicants (Johansson et al., 2009). The human brain undergoes rapid development beginning in the third trimester of pregnancy and continues into the first two years of age (Nassar et al., 2011). In mice, this period of rapid brain development occurs at three to four weeks of age, and peaks at postnatal day ten (Johansson et al., 2009).

Mice that were dosed with either 11.3 mg PFOS/kg of body weight or 8.70 mg PFOA/kg of body weight showed significantly increased levels of four proteins involved in brain development (Johansson et al., 2009). The results of changes of protein levels in mice may indicate possible brain development problems in humans. If increases of these proteins involved in brain development also occur in humans with exposure to PFOS and/or PFOA, abnormal brain development could occur. Neurodegeneration may possibly occur with exposure to PFOS and/or PFOA, which could affect cognitive function (Johansson et al., 2009).

In humans, physical measurements of the size of head can be easily done, and may indicate possible brain abnormalities. Brain growth and development have been assessed by measuring head circumference. A study conducted in the U.S. found a negative association between head circumference in newborns and their cord blood concentrations of PFOS and PFOA (Apelberg et al., 2007b). However, a different study did not find any significant associations between head circumference and the concentration of PFOS or PFOA (Fei et al., 2008). The results from these studies may indicate negative associations between brain development and concentrations of PFOS and PFOA in the body, but more studies are needed before conclusions are warranted.

1.9.2. Effects on Thyroid Hormones

Thyroid hormones are involved in brain development, and low levels of thyroxine (T_4) can cause mental delay in humans (Inoue et al., 2004). In a study that dosed pregnant rats with PFOS, both total T_4 and free T_4 serum levels were lower than controls in all dose concentrations (1 mg/kg to 10 mg/kg) (Lau et al., 2003). However, by the time of weaning, the concentration of total T_4 in the rat pups had recovered. Additionally, levels of T_4 and triiodothyronine (T_3) in the pregnant rats were lower than controls, which could indicate availability of thyroid hormones to be passed from dam to pup. This study also looked at the effects of PFOS on mice, and found that levels of T_4 in serum were only lower in mice dosed at higher concentrations (5 mg/kg and 10 mg/kg). No significant changes in the concentrations of T_3 or thyroid-stimulated hormone were observed between the PFOS dosed pups and the controls (Lau et al., 2003). Other studies agree with these results, where levels of T_3 were not affected by PFOS exposure, but

levels of T_4 in serum were significantly lowered. Both exposures *in utero* and postnatal exposure via lactation were determined to be important in lowering levels of T_4 in serum in a cross-fostering study (Yu et al., 2009).

The results concerning thyroid hormone changes in laboratory studies can be compared to human studies. Studies done on adults, including pregnant women (Chan et al., 2011), have shown inconsistent results regarding correlations between PFC levels in blood and thyroid disease. Some studies have found correlations between PFCs and thyroid disease (Melzer et al., 2010), but others have not (Chan et al., 2011). One study found no correlation between levels of PFOS in umbilical cord blood and levels of thyroid-stimulating hormone or free T_4 in fifteen samples, where the cord blood samples ranged in PFOS concentration of 1.6 ng/mL to 5.3 ng/mL (Inoue et al., 2004). Whether these endpoints were not observed in humans because the concentration of PFOS was too low to elicit toxicity or the effect to human T_4 levels differs from rodents is yet to be determined.

1.9.3. Effects on Body Weight

Changes in body weight have been observed with exposure to many different environmental pollutants (Hines et al., 2009), and therefore, it is important to investigate the effects PFCs may have on body weight. When monitored for the first 22 days of life, mouse pups whose dams were exposed to 1 mg/kg/day of PFOA during gestation showed significantly lower weight than control mice on some days but not significantly different weights from control on other days (Abbott et al., 2007). Mice dosed with the same amount of PFOA in another study showed significantly lower body weight than controls

at the time of weaning, but not at other times in life (Hines et al., 2009). Mouse dams that were dosed with 5 mg/kg/day of PFOA during gestation had pups that had significantly lower body weight than control mice and mice dosed with lower concentrations of PFOA at the age of one day, weaning, and 18 months (Hines et al., 2009). Another study found that rats exposed to high doses of PFOS had lower weights (at birth and throughout life) (Lau et al., 2003). Additionally, live mouse fetuses at gestation day 18 (full term) showed body weights 20% lower than controls with dosing of 20 mg/kg/day. However, no significantly different body weights were observed in mouse fetuses that had dams dosed 10 mg/kg PFOA or lower (Lau et al., 2006), showing the importance of the dose concentration on endpoints.

There have been conflicting results found in regards to correlations between PFC exposure and effects on birth weight in humans. Lower birth weights have been reported in animals that have been exposed to PFCs before birth (Andersen et al., 2010). In humans, there have been studies which concluded that there was no correlation between PFC levels in blood and birth weight (Hamm et al., 2010; Inoue et al., 2004; Monroy et al., 2008; Savitz et al., 2012), but also studies which concluded there was a correlation (Apelberg et al., 2007b; M. Chen et al., 2012; Fei et al., 2007; Whitworth et al., 2012). One study found no trend concerning PFOA maternal serum concentrations and birth weights below 5.5 pounds, but did find high levels of PFOA were related to birth weights over 5.5 pounds (Stein et al., 2009). They also determined that the risk of a birth weight below 5.5 pounds increased with increasing PFOS maternal serum levels (Stein et al., 2009). Additionally, prenatal exposure to PFOS and PFOA may be correlated to lower

weight and body mass index in early life in humans, where males were more affected than females (Andersen et al., 2010).

Ponderal index is a measurement involving the ratio of birth weight to length, and is a tool for examining thinness at birth and abnormal growth. Ponderal index is a measurement that can easily be done on humans to assess growth. Low ponderal index increases the risk of abnormal perinatal growth (Apelberg et al., 2007b). In humans, one study found a negative association between ponderal index and cord blood concentrations of PFOS and PFOA (Apelberg et al., 2007b), however, another study did not find any significant associations (Fei et al., 2008).

In addition to lower body weights in rodents found with high doses of PFOA, higher body weights later in life with low doses have been observed. One study found that mice exposed to PFOA during their developmental stages with low doses of PFOA (dam dosed with 0.01 mg/kg/day, 0.1 mg/kg/day and 0.3 mg/kg/day) had higher weights than the controls later in life (Hines et al., 2009). This study also investigated serum insulin and leptin levels, as these may be involved in weight gain. The mice in the 0.01 mg/kg/day and 0.1 mg/kg/day groups had significantly higher body weight, insulin levels, and leptin levels than controls at age 21 and 33 weeks. The elevated serum concentrations of insulin and leptin may be involved in the result of overweight mice. In humans, both insulin-resistance and leptin-resistance are related to being overweight (Hines et al., 2009).

In adults, studies have investigated body weight and insulin concentrations and how these levels may correlate to concentration of PFCs. In the U.S., participants from the National Health and Nutrition Examination Survey (NHANES) have been evaluated

for these parameters. The data from this survey evaluated adults and adolescents over 12 years of age. A positive correlation was determined between serum PFOS concentration and increased blood insulin levels in adults, but no significant correlation was observed concerning PFOA (X. H. Liu et al., 2010). Another study showed very little association between levels of PFOS and PFOA and either body weight or insulin resistance. A positive association was observed in men 60 to 80 years of age and PFOS concentrations, but a negative association was observed in males 12 to 59 years of age (Nelson et al., 2010). It is difficult to draw conclusions from studies that evaluate adolescents and adults, as the results may or may not reflect developmental exposure to PFOS and PFOA.

1.9.4. Gestational Effects

Laboratory studies have shown negative effects from PFC exposure to rodents in terms of litter resorptions, which could correspond to problems carrying a fetus to term in humans. For example, full litter resorption has been observed in mice with increasing levels of PFOA exposure; in particular, significant increases in resorption after exposure to 5 mg/kg/day and higher (Lau et al., 2006; Abbott et al., 2007). At much higher exposure levels of PFOA (40 mg/kg/day) all pregnancies in mice were lost (Lau et al., 2006).

In mice, the average gestational period was prolonged by exposure to PFOA in a laboratory study (Lau et al., 2006). When mice were dosed at 20 mg/kg/day, the length of their gestational period was increased by approximately twelve hours. In this study, it was also observed that occurrence of stillbirths and neonatal mortality was increased with exposure to PFOA.

A study in the U.S. found no correlation between PFOA or PFOS and miscarriages in women who lived near a contaminated ground water site (Stein et al., 2009). The average concentration of PFOA in the blood serum of women who currently or previously lived in the contaminated area and had been pregnant in the proceeding five years was 48.8 ng/mL. They found no correlation between PFOS levels and birth defects, but a higher risk of birth defects when maternal serum levels of PFOA were over the 90th percentile (121 ng/mL to 894 ng/mL) (Stein et al., 2009). The same study group was used to evaluate birth defects over a larger range of time (1990 to 2006) but it was also found that there was no association between PFOA concentration and miscarriages (Savitz et al., 2012).

A Norwegian study of preterm births found that there was a trend of decreasing odds ratios with increasing concentrations of PFOS or PFOA, although the number of participants with preterm births was low (Whitworth et al., 2012). However, other studies have found no association between gestational age (Apelberg et al., 2007b; Hamm et al., 2010) or preterm births (Stein et al., 2009) and concentrations of PFOS or PFOA. It is unclear whether PFOS or PFOA induce gestational effects on humans, but most studies evaluating these effects showed no correlation for PFOS or PFOA.

1.9.5. Liver Weight Changes

When PFCs are present in the body, they can be found in the liver (Olsen et al., 2005) so it is important to explore possible developmental effects PFCs may have on the liver. It has been observed that relative liver weights in rat and mouse pups exposed to PFOS were significantly lower than controls (Lau et al., 2003). Changes in liver weight

with exposure to PFOA have also been observed in laboratory studies. Mice pups exposed to PFOA showed significant, dose-dependent increases in relative and absolute liver weights (Abbott et al., 2007; Macon et al., 2011).

These results demonstrate that increases in liver weight are associated with both PFOS and PFOA. Whether the liver weights in human infants are correlated to concentrations of PFOS and PFOA in infant serum is yet to be determined.

1.9.6. Activation of Peroxisome Proliferation Activated Receptors

Peroxisome proliferator activated receptors (PPARs) regulate gene expression. A subtype, PPARα, is a ligand-activated nuclear receptor that responds to endogenous and exogenous ligands (Abbott et al., 2007). The PPARα pathway is involved in maintaining glucose and lipid homeostasis. Additionally, the pathway is involved in regulating inflammatory responses and cell proliferation and differentiation. Effects of PFOA have been a recent concern, as activation of PPARα by PFOA exposure is thought to contribute to tumor formation in the liver of rats (Abbott et al., 2007).

PPARs are found in rodents (Abbott et al., 2007) and humans (Abbott et al., 2010) during gestation. Human fetuses have been found to express PPARs at the same levels as adults (Abbott et al., 2010). PFOA is a known PPARα agonist, as *in vitro* studies have shown that both mouse and human cells exhibit activation of PPARα with exposure to PFOA (Maloney & Waxman, 1999). Therefore, exposure to PFOA during gestation could cause developmental toxicity (Abbott et al., 2007).

A study comparing PPARα knockout mice (mice which did not express genes for PPARα) and wild-type mice found that PFOA did affect development through the

PPARα pathway. Wild-type mice weighed significantly less than controls on certain days before weaning, while knockout mice showed no difference in weight from the controls. Survival of mice pups from birth to weaning was greatly reduced with PFOA exposure in wild-type mice, while knockout mice showed negligible effects in pup survival (dosed from 0.1 mg to 3.0 mg/kg) (Abbott et al., 2007). These differences in observed endpoints between knockout mice and wild-type mice demonstrate the importance of the PPARα pathway in developmental toxicity of PFOA. PFOS has not been shown to induce developmental effects on rodents through the PPARα pathway, and is a weaker agonist of PPARα than PFOA (Abbott et al., 2009). Whether or not the PPARα pathway in human infants is affected is still unknown.

1.9.7. Lungs

Asthma is a respiratory disease resulting from constricted airways. Asthma symptoms include wheezing, coughing, tightness in the chest and shortness of breath (Holgate, 2011). The most prominent symptom of asthma is wheezing or whistling in the chest, which can range from mild to severe (Beasley et al., 1998). Severe wheezing may require the use of inhaled corticosteroid or hospital-based care in order to be controlled (Herr et al., 2012). There was an increase of incidence of asthma in children all over the world from the 1970s to the early 2000s (Boner et al., 2002), and then many countries, including Canada, have seen a decrease or leveling off since then (Thomas, 2010). The incidence of asthma followed a similar temporal pattern of increase then decrease in use of many PFCs (M. Wang et al., 2011). It is thought that indoor allergens are a direct environmental cause of asthma (Duffy et al., 1998). Therefore, the increased use of PFCs

in the indoor environment and the increased incidence of asthma until around the time of PFOS phase-out have raised the question of whether PFCs may be involved in the occurrence of asthma in children.

It is believed that sensitization to certain allergens, such as those found on dust mites, dogs, and cats, are the most important environmental risk factors for childhood asthma (Boner et al., 2002). It is not known definitively what the cause of asthma in children is, although these factors have been shown to be closely associated (Boner et al., 2002).

In murine models, both PFOS and PFOA have shown to affect the lungs. Rat pups that were prenatally exposed to PFOS showed histological changes in the lungs and laboured breathing (Grasty et al., 2005). These changes were suggestive of lung immaturity; however, further investigation indicated that laboured breathing was not due to lung immaturity and a cause could not be determined (Grasty et al., 2005). Another study that prenatally exposed rat pups to PFOS found histological changes in the lungs, but also an abundance of cells which had undergone apoptosis (programmed cell death) in a 2.0 mg/kg/day group (T. Chen et al., 2012). Atelectasis (collapse of the lungs) was observed in a portion of rat pups that were prenatally exposed to PFOS at a high dosage (10 mg/kg bw) (Yahia et al., 2008).

Mice pups that were prenatally exposed to PFOA showed changes in gene expression that were dose-dependent (Rosen et al., 2007). The genes in lungs which were most affected were associated with fatty acid catabolism, including up-regulation of a gene which has been used as a marker for PPARα activation (Rosen et al., 2007).

Similarly, another study found that PPARα was expressed at higher levels in lungs of mice pups that were prenatally exposed to PFOA than control pups (Abbott et al., 2012).

In humans, one known study has been conducted which investigated correlations between wheezing in infants and concentrations of PFCs. This Japanese study found no association between wheezing in infants at 18 months of age and the levels of PFOS or PFOA in maternal serum (Okada et al., 2012). Whether or not PFC exposure is associated with harmful effects to human lungs is still under investigation.

1.10. Summary of Chapter 1

Humans are exposed to PFCs through many consumer products. PFCAs and PFSAs are stable compounds which are persistent in the environment, animals, and humans. Nowadays, the most common method of measuring PFCs in matrices such as blood is by LC-MS/MS. Using LC-MS/MS with online SPE to evaluate PFCs has led to low detection limits and good reproducibility in human samples (Haug et al., 2009). The most commonly detected PFCs in human blood are PFOS and PFOA, which have been typically detected at ng/mL levels (Chan et al., 2011; Hamm et al., 2010; Olsen et al., 2012).

Infants can be exposed to PFCs pre- and postnatal sources. PFCs can be transferred from mother to fetus through placental transfer (Fromme et al., 2010; Midasch et al., 2007). Infants may be exposed to PFCs via breast milk (Llorca et al., 2010; Tao et al., 2008b), infant formula (Llorca et al., 2010), and indoor air and dust (Harrad et al., 2010; Shoeib et al., 2011). Toxicity studies using animals have shown that PFCs can elicit various developmental effects (Abbott et al., 2007; Grasty et al., 2005; Johansson et

al., 2009; Lau et al., 2003). Human studies on infants have not concluded whether correlations exist between PFCs in blood and developmental effects (Apelberg et al., 2007b; M. Chen et al., 2012; Fei et al., 2008; Monroy et al., 2008). Further investigation is warranted to examine various characteristics that may affect PFC exposure and whether PFCs are related to adverse health outcomes in humans.

1.11. References

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Chapter 2 Evaluation of PFC Concentrations in Human Plasma and Associations of PFC Concentrations with Maternal, Infant, and Home Characteristics

2.1. Introduction

PFCs have been widely used in a large variety of consumer products for over 50 years, but the exposure routes and toxic effects of PFCs in humans are still unclear. When evaluated, the half-lives of non-volatile PFCs like PFOS, PFOA, and PFHxS were on the order of years (Burris, 2002; Olsen et al., 2007). PFCs are persistent and have been found in animals, humans, and the environment all over the world (Houde et al., 2006). The manufacturing of PFOS-related compounds was voluntarily phased out by the principal manufacturer in 2000 (Burris, 2002). Animal studies have shown PFCs to have toxic effects (Lau et al., 2004). The toxicity and exposure risk of PFCs to humans is still under investigation.

We hypothesized that PFC concentrations in human maternal and infant plasma would be correlated to maternal, infant, and home characteristics. We hypothesized that greater PFC concentrations would be associated with increased incidences of wheezing and developmental effects in infants. Additionally, PFC concentrations would be higher in participants whose homes contained more products that were thought to contain PFCs. In order to evaluate these possible correlations, the concentrations of 17 PFCs were measured in 711 total maternal and infant plasma samples and these concentrations were compared to survey results.

Various developmental effects associated with PFC exposure have been noted in both animal and human studies. Altered brain development was observed via changed levels of proteins in the brain of mice that were given high doses of PFOS or PFOA

(Johansson et al., 2009). In humans, altered brain development could change the head circumference, and smaller head circumference has been correlated with PFOS and PFOA concentrations in newborns (Apelberg et al., 2007). Lowered body weight has been observed in newborn mouse pups when the dams were given high doses of PFOA (Hines et al., 2009), and has been correlated with PFOS and PFOA levels in humans (Apelberg et al., 2007). Longer gestation time was observed in mice that were given high doses of PFOA (Lau et al., 2006). In humans, the odds ratio of preterm birth was inversely related to PFC concentrations in blood in one study with a small number of preterm birth study participants (Whitworth et al., 2012). However, there have been human studies that contradict the findings of each of these associations of PFCs with developmental effects. Changes in lung development resulting in laboured breathing were observed in rat pups when the dam was dosed with high levels of PFOS (Grasty et al., 2005). In humans, only one study has looked at associations between wheezing in infants and PFOS and PFOA concentrations in maternal blood, and found no association (Okada et al., 2012). The contradictory results and limited number of studies warrants further investigation of possible associations between concentrations of PFCs and developmental effects in humans.

The most commonly used PFCs, such as PFOS and PFOA, are typically found in human plasma or serum at concentrations in the ng/mL level (Calafat et al., 2007; Fromme et al., 2009; Haines & Murray, 2012; Olsen et al., 2012). However, occupationally exposed persons have had PFCs measured at the μg/mL level (Burris, 2002; Fromme et al., 2009; Olsen et al., 2007; Olsen et al., 1998; Olsen et al., 2003; Sakr et al., 2007). It is unknown what concentrations of PFCs cause toxic effects in humans.

PFCs are transferred from mothers to infants through the placenta, and cord blood samples generally contain lower levels of PFCs than maternal samples. In Canada, cord blood samples have been found with a mean concentration of 1.8 ng/mL for PFOS and 1.1 ng/mL for PFOA (Beesoon et al., 2011) and 7.2 ng/mL for PFOS and 1.9 ng/mL for PFOA (Monroy et al., 2008). Maternal samples taken during pregnancy from 2004 to 2008 had mean concentrations of 18.3 ng/mL for PFOS and 2.5 ng/mL for PFOA (Monroy et al., 2008), 9.0 ng/mL for PFOS and 2.1 ng/mL for PFOA (Hamm et al., 2010), 7.39 ng/mL for PFOS and 1.35 ng/mL for PFOA (Chan et al., 2011), and 5.5 ng/mL for PFOS and 1.8 ng/mL for PFOA (Beesoon et al., 2011), where PFOS showed a decreasing trend in more recent sampling years. A decreasing trend of various PFCs, including PFOS and PFOA, has been observed in human blood plasma and serum in the U.S. and Europe (Glynn et al., 2012; Haug et al., 2009a; Olsen et al., 2012). Shorter chain-length PFCs are being used as replacements for longer chain-length PFCs because they are thought to be less toxic and less bioaccumulative (Ahrens et al., 2009; Olsen et al., 2009; Wilhelm et al., 2010; Conder et al., 2008). Consequently, increasing levels of shorter chain-length PFCs have been observed in recent human blood samples from Sweden (Glynn et al., 2012).

The instrumentation most commonly used to measure PFCs in blood in recent years is LC-MS/MS. LC-MS/MS methods can obtain detection limits down to parts per trillion levels (Haug et al., 2009b). These levels of high sensitivity are needed to measure the levels of PFCs in blood and other biological tissues. LC-MS/MS is advantageous over GC-MS in this type of study because non-volatile PFCs, such as PFOS and PFOA, must be derivatized for detection in GC-MS (Chu & Letcher, 2009). Online SPE is a clean-up

technique that can be less time consuming and decreases the chance of analyte loss over off-line clean-up techniques. Off-line clean-up techniques require extensive sample preparation before the sample is injected into the LC-MS system (Yeung et al., 2009). Less sample preparation is required for online SPE, and therefore, a large volume of samples can be measured in a short timeframe with less risk of losing or contaminating the samples during preparation. Online SPE methods can be used for a large volume of samples (Haug et al., 2009b) and therefore, it was ideal to use online SPE for this study.

PFCs are found in many consumer products because of their unique properties. It is estimated that food is the main source of exposure of PFCs (Haug et al., 2010; Tittlemier et al., 2007). PFCs have been found in food and food products such as drinking water, fish, beef, pizza, microwave popcorn, fast food, and food packaging (D'Hollander et al., 2010; Tittlemier et al., 2006; Tittlemier et al., 2007). PFCs have also been found in household air and dust, and these sources are both possible exposure routes to humans (Shoeib et al., 2011). PFCs are present in almost every human blood sample tested, most likely due to the ubiquitous presence of PFCs in household and food items. However, the contribution of items in the home to the levels of PFCs in blood is not well understood.

This study is part of the Canadian wide CHILD study. The CHILD study investigates the impact of environmental factors on young children's health. As a part of CHILD, this study aimed to investigate what factors influenced PFC distributions in plasma and whether PFCs in plasma were associated with infant health in Winnipeg, Manitoba. Blood plasma samples and survey results from over 500 participants were supplied by CHILD for this study. To our knowledge, no previous evaluation of concentrations of PFCs in people from Winnipeg, Manitoba has been conducted.

The large number of participants allowed for assessment of PFC exposure from people with many different maternal, home, and infant characteristics. Previously, cohort studies elsewhere have measured PFCs in blood and gained insight of temporal trends (Kato et al., 2011), concentrations in pregnant women (Woodruff et al., 2011), and influence of participant characteristics on blood PFC levels (Calafat et al., 2007). However, there are few cohort studies which evaluate PFCs in pregnant women at different time points and their infants for a large group of participants.

This is the first known study to compare PFC concentrations to the incidence of wheezing in infants in North America. Additionally, this is the first known study to investigate exposure of PFCs in people from Winnipeg, Manitoba. The data collected from extensive surveys filled out by participants and/or their physicians led to comparisons between PFCs in plasma and home, maternal, and infant characteristics; many which had not been performed before.

2.2. Methods and Materials

2.2.1. Chemicals and Reagents

Native standards perfluoro-*n*-pentanoic acid (PFPA), perfluoro-*n*-hexanoic acid (PFHxA), perfluoro-*n*-heptanoic acid (PFHpA), perfluoro-*n*-octanoic acid (PFOA), perfluoro-*n*-nonanoic acid (PFNA), perfluoro-*n*-decanoic acid (PFDA), perfluoro-*n*-undecanoic acid (PFUA), potassium perfluoro-1-butanesulfonate (PFBS), sodium perfluoro-1-hexanesulfonate (PFHxS), sodium perfluoro-1-octanesulfonate (PFOS), sodium perfluoro-1-decanesulfonate (PFDS), 2*H*-perfluoro-2-decanoic acid (8:2 FTUCA), perfluoro-1-octanesulfonamide (FOSA), *N*-methylperfluoro-1-

octanesulfonamide (MeFOSA), *N*-ethylperfluoro-1-octanesulfonamide (EtFOSA), 2-(*N*-methylperfluoro-1-octanesulfonamido)-ethanol (MeFOSE), 2-(ethylperfluoro-1-octanesulfoamido)-ethanol (EtFOSE) and corresponding isotopically labeled standards perfluoro-*n*-[1,2-$^{13}C_2$]hexanoic acid (PFHxA-$^{13}C_2$), perfluoro-*n*-[1,2,3,4-$^{13}C_4$]octanoic acid (PFOA-$^{13}C_4$), perfluoro-*n*-[1,2,3,4,5-$^{13}C_5$]nonanoic acid (PFNA-$^{13}C_5$), perfluoro-*n*-[1,2-$^{13}C_2$]decanoic acid (PFDA-$^{13}C_2$), perfluoro-*n*-[1,2-$^{13}C_2$]undecanoic acid (PFUA-$^{13}C_2$), sodium perfluoro-1-hexane[$^{18}O_2$]sulfonate (PFHxS-$^{18}O_2$), sodium perfluoro-1-[1,2,3,4-$^{13}C_4$]octanesulfonate (PFOS-$^{13}C_4$), 2*H*-perfluoro-[1,2-$^{13}C_2$]-2-decanoic acid (8:2 FTUCA-$^{13}C_2$) perfluoro-1-[$^{13}C_8$]octanesulfonamide (FOSA-$^{13}C_8$), *N*-methyl-d_3-perfluoro-1-octanesulfonamide (MeFOSA-d_3), *N*-ethyl-d_5-perfluoro-1-octanesulfonamide (EtFOSA-d_5), 2-(*N*-deuteriomethylperfluoro-1-octanesulfonamido)-1,1,2,2-tetradeuterio-ethanol (MeFOSE-d_7), and 2-(*N*-deuterioethylperfluoro-1-octanesulfonamido)-1,1,2,2-tetradeuterioethanol (EtFOSE-d_9) were purchased from Wellington Laboratories (Guelph, ON, Canada). The chemical purity of all standards was 98% or greater and the isotopic purity of labeled standards was 94% or greater. The stock solution of 8:2 FTUCA was in isopropanol and all other standards were in methanol. All standards were stored at approximately -20^{o}C in polypropylene vials to minimize degradation and volatilization.

HPLC-grade acetonitrile, methanol, and isopropanol were obtained from Fisher Scientific (Ottawa, ON, Canada). Reagent grade formic acid was purchased from Sigma-Aldrich (Oakville, ON, Canada). De-ionized water was purified as MilliQ water (18 MΩ-cm) using a Millipore Synergy System (Billerica, MA, U.S.). HPLC-grade ammonium acetate was purchased from Sigma Aldrich (St. Louis, MO, U.S.). BD vacutainers™ Plus made from a formulation of polyethylene terephthalate were obtained from Becton,

Dickinson, and Company (Mississauga, ON, Canada). Bovine plasma was purchased from Rockland Immunochemicals (Gilbertsville, PA, U.S.).

2.2.2. Sample Collection

Blood samples (one to three mL) were collected from CHILD volunteers who lived in or close to Winnipeg, Manitoba. A subset of CHILD samples was analyzed for this study. Maternal samples were collected during the second trimester of pregnancy and/or one year after delivery of the baby. Prenatal maternal samples were collected between January 28, 2010 and November 15, 2011. A subset of 414 prenatal samples was analyzed for this study. Postnatal maternal samples were collected approximately one year after the mother had delivered the baby between June 9, 2010 and May 3, 2012. A subset of 247 postnatal samples was analyzed for this study. Cord blood samples were collected at time of delivery. Cord blood samples were collected between March 31, 2010 and August 18, 2011. A subset of 50 cord blood plasma samples, which had corresponding prenatal samples, was analyzed for this study. Samples were archived at -20°C until further analysis.

Participants filled out extensive surveys regarding home characteristics, their health, and their infant's health at various time points as part of the CHILD study. Surveys used for this study were completed during pregnancy, soon after birth of the infant, three months after birth, six months after birth, and one year after birth. Use of CHILD human tissue samples and survey information was done under approved human ethics protocols of the University of Manitoba and The University of Winnipeg.

2.2.3. Standards and Sample Preparation

Calibration curve standards were prepared from working PFC standard solutions. Working PFC standard solutions of 0.25, 2.5, 25, and 100 pg/μL were prepared in methanol in polypropylene vials. In order to prevent degradation of analytes, working standard solutions were only used if prepared in the previous 96 days. Working PFC standard solutions were diluted to 110 μL in methanol to reflect plasma concentrations of 0.05, 0.1, 0.2, 0.5, 1.0, 5.0, 20, and 50 ng/mL. To these diluted solutions, 110 μL of 0.1% formic acid was added. The solutions were vortexed and analyzed within five days of preparation.

Calibration curves were plotted as relative concentration (peak area of native compound divided by peak area of internal standard) versus concentration. The internal standard for most analytes was an isotope of the analyte. However, for a few analytes, isotopic internal standards were not available so internal standards were isotopes of other PFCs with similar structures to the analyte. A linear regression weighting of 1/x was used for all analytes.

Samples for method validation were prepared from 50 μL of bovine plasma using a modified procedure based on methods by Mosch et al., 2010. In a 2 mL centrifuge tube, 10 μL of 5.0 pg/μL internal standard mixture, 10-25 μL of working PFC standard solutions, and 35-60 μL of methanol were added to 50 μL of bovine plasma. The solutions were vortex mixed then centrifuged at 14,000 rpm for ten minutes. The supernatant was collected and added to 60 μL of acetonitrile. The solutions were vortex mixed and stored at -20^{o}C for one hour. The solutions were centrifuged a second time at 14,000 rpm for ten minutes. The supernatant (110 μL) was collected and combined with

110 μL of 0.1% formic acid in a polypropylene autosampler vial. The calibration curves were prepared to give concentrations of 0.05, 0.2, 0.5, 1.0, 5.0, 20, and 50 ng/mL plasma, as well as a plasma sample which was not spiked with PFCs.

All plasma samples were stored at -20^{o}C then thawed at room temperature prior to use. Whole blood (one to three mL) was collected in vacutainers containing heparin and then the blood was centrifuged for ten minutes at 500*g*. The resulting supernatant (plasma) was collected and stored in 96-well plates or polypropylene tubes.

The plasma extraction procedure used modified methods based on Mosch et al., 2010. In a 2 mL centrifuge tube, 20 μL of 2.5 pg/μL internal standard mixture and 50 μL of methanol were combined with 50 μL of plasma. The solutions were vortex mixed then centrifuged at 14,000 rpm for ten minutes. The supernatant was collected and added to 60 μL of acetonitrile. The solutions were vortex mixed and stored at -20^{o}C for one hour. The solutions were centrifuged a second time at 14,000 rpm for ten minutes. The supernatant (110 μL) was collected and combined with 110 μL of 0.1% formic acid in a polypropylene autosampler vial. The solution was vortexed and then subjected to LC-MS/MS analysis using online SPE.

2.2.4. Instrumental Analysis

The online SPE LC-MS/MS system consisted of a HTC PAL autosampler (CTC Analysis, Zwingen, Switzerland), two Agilent LC pumps (Agilent Technologies, Mississauga, ON, Canada), and an Agilent 6410 triple quadrupole MS/MS. The CTC autosampler contained a 6-port switching valve, and the binary LC pump contained a 10-port switching valve. The quaternary pump (model G1311C) was responsible for loading

the analytes onto the SPE column, and the binary pump (model G1312B) was responsible for backflushing the analytes off the SPE column onto the analytical column.

An EXP® trap and in-line holder (C18-ES 2.7 μm, 10 × 4 mm) from Optimize Technologies (Oregon City, OR, U.S.) was used as an online SPE column. A ZORBAX Eclipse Plus C18 column (1.8 μm, 50 mm × 2.1 mm) from Agilent Technologies (Mississauga, ON, Canada) was used as an analytical column with a SecurityGuard Cartridge C18 column (3 μm, 4 mm × 2.0 mm) from Phenomenex (Torrance, CA, U.S.) as the analytical guard column. To avoid possible contamination from any PTFE or other fluoropolymers present in the binary pump, a ZORBAX Eclipse Plus C18 column (3.5 micron, 30mm × 4.6mm) from Agilent Technologies (Mississauga, ON, Canada) was attached between the pump and the 10-port switching valve in order to trap any PFCs that may be present.

Sample cleanup by online SPE was a modification of published methods (Gosetti et al., 2010; Haug et al., 2009b). At initial time, 120 μL of sample was injected into the 6-port valve of the CTC autosampler (Figure 2.1). The 6-port valve was in position 1 while the syringe injected the sample into the port, then switched to position 2 once the syringe had delivered the entire sample to the port. The sample was loaded into a 500 μL sample loop, and then the 6-port valve switched to position 2 to flush the sample to the SPE column. The sample was retained on the SPE column by 0.1% formic acid in MilliQ water and methanol (95:5) flowing from the quaternary pump. After 1.4 minutes the 10-port valve (Figure 2.2) switched and the sample was backflushed off the SPE column onto the analytical column by 2 mM ammonium acetate in MilliQ and acetonitrile flowing from the binary pump. The analytes were then separated on the analytical column

using a flow rate of 0.5 mL per minute at 40^{o}C. Mobile phase gradients from the two pumps are displayed in Table 2.1. Between 1.4 minutes and 6.85 minutes, the quaternary pump system was flushed with various solvents and between 6.85 minutes and 11 minutes the quaternary pump system and SPE column were flushed with various solvents to eliminate carryover of analytes.

Figure 2.1. Schematic of the 6-port switching valve.

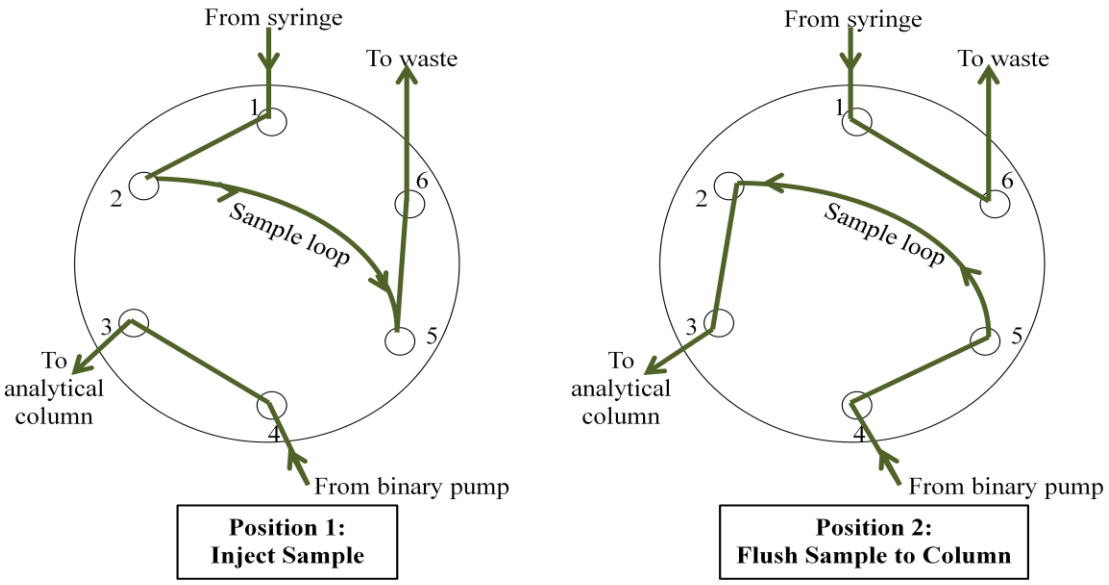


Figure 2.2. Schematic of the 10-port switching valve.

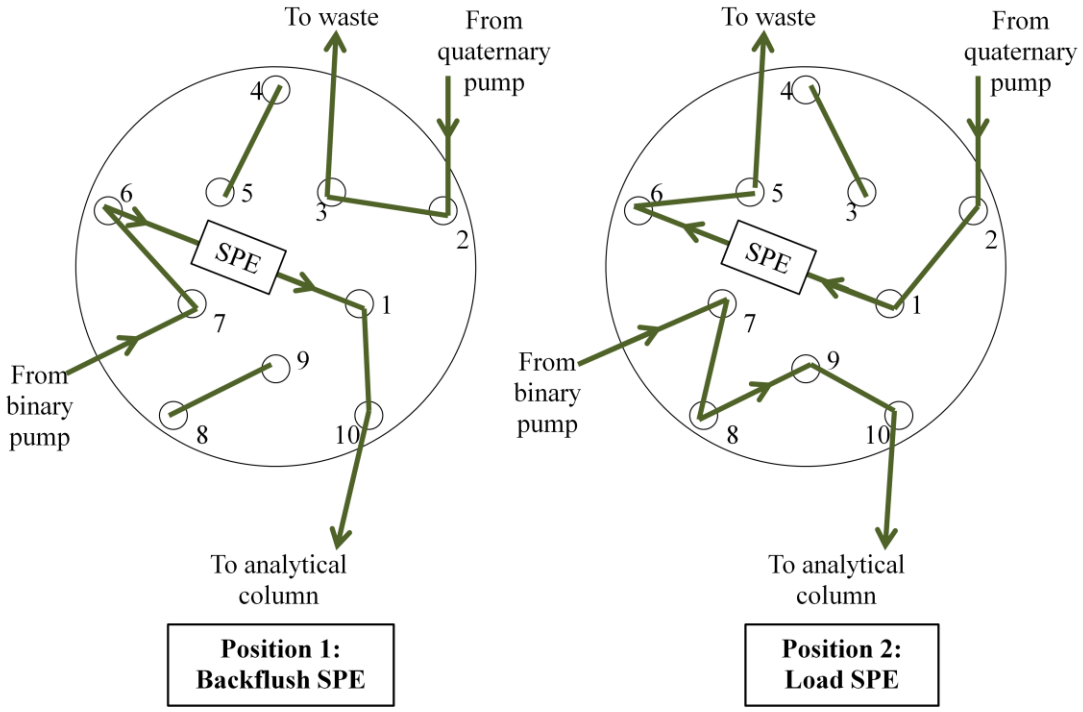


Table 2.1. Positions of the binary pump 10-port valve and composition of solvents used in the liquid chromatography analysis. Acetonitrile is abbreviated as ACN, methanol as MeOH, isopropanol as IPA, and ammonium acetate as AA.

Time (min)	Quaternary Pump Solvent Percentage				Binary Pump Solvent Percentage	Location of Analytes	10-Port Valve in Binary Pump
	0.1% Formic Acid	ACN	MeOH	50:50 IPA: MilliQ	2mM AA in MilliQ		
0.0	95	0	5	0	15	SPE	2
1.4	95	0	5	0		Backflushed off SPE onto analytical column	1
1.49	95	0	5	0	Gradient from 15 to 60		
1.5	0	50	50	0			
4.49	0	50	50	0			
4.5	0	0	0	100			
5					60		
5.6					67		
5.61					90		
6.85						MS/MS	2
7.6							
8.49					Gradient from 90 to 15		
8.5	0	50	50	0	15		
9.49	0	50	50	0			
9.5	95	0	5	0			

The mass spectrometry analysis was performed using dynamic multiple reaction monitoring using ESI in negative mode. The curtain gas temperature was set to 300^{o}C at a flow of 10 L per minute. The nebulizer pressure was set to 55 psi and the capillary voltage was -2000 V.

2.2.5. Statistical Analysis

Statistical analysis was performed using SPSS Statistics software (version 19.0.0) and GraphPad PRISM software (version 5.01). A significance level of $\alpha = 0.05$ was used. Statistical comparison tests were only performed on analytes with median values above the LOQ.

Comparisons of PFCs in plasma at different time points, correlations between PFCs in plasma, and concentrations of PFCs in plasma compared to home characteristics, incidence of wheezing, duration of breastfeeding, and maternal characteristics was performed on the measured concentrations of PFCs, using appropriate nonparametric tests (Spearman rank, Kruskal-Wallis test, Mann-Whitney test, Wilcoxon paired test).

Principal component analysis (PCA) was used to assess exposure and trends with maternal PFC concentrations. The proportions of each PFC relative to the sum of total PFCs were used as the variables for PCA. Random values between zero and the LOQ were substituted for concentrations under the LOQ, the proportions were calculated, and then natural log transformed. Survey data regarding home characteristics and maternal health were used to evaluate exposure and trends within the PCA data. Because the proportions of PFCs were natural log-transformed, parametric statistical tests (one-way ANOVA, unpaired *t*-test) were used.

Multiple linear regression was performed on the natural log-transformed concentrations of PFCs in maternal plasma. Random values between zero and the LOQ were substituted for concentrations under the LOQ. Outcomes that were assessed were infant birth weight, infant birth length, ponderal index, head circumference, and gestational age. The independent variables assessed for each of these outcomes were maternal age, whether or not the mother smoked during pregnancy, whether or not the mother had high blood pressure during pregnancy, whether or not the mother had diabetes during pregnancy, parity of the mother, and infant sex. Gestational age was used as an independent variable for birth weight, birth length, and head circumference. The method of delivery (vaginal or caesarian section) was used as an independent variable for head circumference.

2.3. Results and Discussion

2.3.1. Method Validation

The fragmentation voltage and collision cell energy were optimized using the Agilent Optimizer program, which selects a fragmentor voltage and collision cell energy based on the highest numbers of ions fragmented over a range of values. The optimized fragmentor and collision cell values and which internal standard were used for each analyte are listed in Table 2.2. The same fragmentor voltage and collision cell energies as the native analyte were used for the corresponding internal standards.

Table 2.2. Optimized fragmentor voltage, collision energies, ion transitions and internal standards for each analyte. (Q) indicates the qualifier ion fragment.

Analyte	Ion Transition (*m/z*)	Fragmentor Voltage (V)	Collision Energy (V)	Internal Standard	Internal Standard Ion Transition (*m/z*)
PFPA	263 → 219	52	0	PFHxA-$^{13}C_2$	315 → 270
PFHxA	313 → 269	53	0		
PFHxA (Q)	313 → 119		16		
PFHpA	362.9 → 319	66	4		
PFHpA (Q)	362.9 → 169		13		
PFOA	413 → 368.9	72	4	PFOA-$^{13}C_4$	417 → 371.9
PFOA (Q)	413 → 168.9		16		
PFNA	463 → 418.9	78	8	PFNA-$^{13}C_5$	468 → 422.9
PFNA (Q)	463 → 168.9		20		
PFDA	513 → 468.9	104	8	PFDA-$^{13}C_2$	515 → 469.9
PFDA (Q)	513 → 269		13		
PFUA	563 → 519	87	8	PFUA-$^{13}C_2$	565 → 520
PFUA (Q)	563 → 269		16		
PFBS	299 → 80	146	30	PFHxS-$^{18}O_2$	402.9 → 84
PFBS (Q)	299 → 98.9		26		
PFHxS	398.9 → 80	166	48		
PFHxS (Q)	398.9 → 99		40		

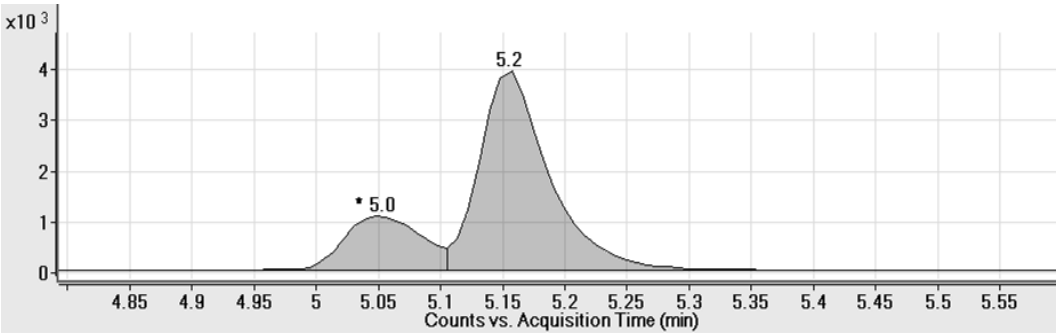
Analyte	Ion Transition (*m/z*)	Fragmentor Voltage (V)	Collision Energy (V)	Internal Standard	Internal Standard Ion Transition (*m/z*)
PFOS	498.9 → 99	198	46	PFOS-$^{13}C_4$	502.9 → 99
PFOS (Q)	498.9 → 80		66		
PFDS	598.9 → 80	230	72		502.9 → 80
PFDS (Q)	598.9 → 99		56		
8:2 FTUCA	457 → 393.1	146	38	8:2 FTUCA-$^{13}C_2$	459 → 394.1
FOSA	497.9 → 78.2	146	38	FOSA-$^{13}C_8$	505.9 → 78.2
MeFOSA	512 → 219.1	90	24	MeFOSA-d_3	515 → 219.1
MeFOSA (Q)	512 → 169.1		24		
EtFOSA	526 → 169	100	28	EtFOSA-d_5	531 → 169
EtFOSA (Q)	526 → 218.5		24		
MeFOSE	616 → 59	86	12	MeFOSE-d_7	623 → 59
EtFOSE	630 → 59.1	98	8	EtFOSE-d_9	639 → 59.1

The product ion with *m/z* of 80 can be most abundant when PFOS is fragmented, but there can be isobaric interferences from compounds in mammalian tissues, and so the fragmentation at *m/z* 99 may be used as the quantifying mass (Hansen et al., 2001). However, not all PFOS isomers produce an ion at *m/z* 99, so this may lead to quantification error (Martin et al., 2004). It may be beneficial to use both 499 → 99 and 499 → 80 as identifying ions for PFOS in order to avoid false positive identification or overestimated concentrations (Martin et al., 2004). One study investigated human metabolites that had a mass of 499±1 as possible interferences and found three isomers of taurodeoxycholic acid with product ions of *m/z* 80 as well (Benskin et al., 2007). Therefore, for PFOS, the fragment of *m/z* 99 was used as the quantifying transition to avoid interference problems with human metabolites at *m/z* 80. To avoid quantification error, the transition of *m/z* 80 was used as the qualifying ion. This method has proven successful in human blood in previous studies (Keller et al., 2010; S. Kim et al., 2011). Even though the less sensitive ion transition was used, all samples analyzed in this study contained concentrations of PFOS above the LOQ. There was no labeled PFDS available at the time of analysis so labeled PFOS was used as the internal standard for PFDS. Labeled PFOS was therefore monitored for two transitions; *m/z* 99 for PFOS and *m/z* 80 for PFDS.

Peaks which were thought to be either bile acids or branched isomers were observed in the chromatograms of the PFSAs (Figure 2.3). This analytical method was not designed specifically to separate branched and linear isomers, and therefore, certain branched isomers may co-elute with the linear isomer peak. For example, the PFOS standard used was the linear isomer. The ratio of qualifier to quantifier ion was

determined from the standard curve, and the sample qualifier to quantifier ratio had to be within ±20% of that ratio in order to be quantified. Most branched isomers of PFOS produce *m/z* 80 and *m/z* 99 ions in different ratios than linear PFOS (Langlois & Oehme, 2006; Riddell et al., 2009). The ratio of qualifier to quantifier ions in samples tested in this study always passed the ±20% criteria, and therefore, it appeared that the contribution of co-eluting branched PFOS isomers may not have contributed significantly to the linear isomer peak area. When branched PFOS isomers are analyzed, they have been found in human blood (Beesoon et al., 2011; Benskin et al., 2007; Karrman et al., 2007) and therefore, it is expected that branched isomers would be present in the samples analyzed in this study. Branched PFOS isomers may be present in blood directly from exposure to manufactured products (Karrman et al., 2007) or from biotransformation of branched precursors (Y. Wang et al., 2011). The limitation of this method is that the branched isomers, which may co-elute, are not quantified separately from the linear isomer so the proportion in each sample is unknown without using isomer-specific chromatographic methods (Benskin et al., 2007; Riddell et al., 2009). Therefore, the proportions of branched PFOS isomers present in samples from this study could not be determined. The concentration of measured linear PFOS will be lower than the total concentration of all PFOS isomers, which some studies have used for their quantitation (e.g. Hanssen et al., 2010). Similar results of a suspected branched isomer peak had been seen in another study that only analyzed the linear isomers of the analytes (Mosch et al., 2010).

Figure 2.3. LC Chromatogram of PFOS in a maternal plasma sample (transition 498.9 → 80). The linear PFOS peak has a retention time of 5.2 minutes and the suspected PFOS isomer or bile acid has a retention time of 5.0 minutes.



The LODs and LOQs were estimated from the signal-to-noise ratio (S/N) of standard PFC solutions or spiked bovine plasma at concentrations 0.05, 0.1, 0.2, and 0.5 ng/mL. The LODs were determined as extrapolated or interpolated concentrations with S/N of three, and LOQs were determined as concentrations with S/N of ten (Table 2.3). The S/N was determined for each sample, and only concentrations with S/N of three or above were reported.

Table 2.3. Estimated limits of detection and limits of quantification in ng/mL for each analyte in matrix-matched bovine plasma or solvent (instrumental). Matrix-matched LOQs were used for all further plasma analyses.

Analyte	Estimated Matrix-Matched LOD	Estimated Matrix-Matched LOQ	Estimated Instrumental LOD	Estimated Instrumental LOQ
PFPA	0.10	0.33	0.066	0.22
PFHxA	0.056	0.19	0.052	0.17
PFHpA	0.021	0.069	0.019	0.063
PFOA	0.020	0.068	0.014	0.048
PFNA	0.059	0.20	0.019	0.063
PFDA	0.0063	0.020	0.0053	0.018
PFUA	0.0094	0.031	0.0077	0.026
PFBS	0.038	0.13	0.012	0.041
PFHxS	0.028	0.093	0.014	0.047
PFOS	0.0078	0.026	0.0089	0.030
PFDS	0.0084	0.028	0.0058	0.019
8:2 FTUCA	0.051	0.17	0.048	0.16
FOSA	0.030	0.10	0.027	0.089
MeFOSA	0.031	0.10	0.028	0.095
EtFOSA	0.019	0.062	0.018	0.061
MeFOSE	0.024	0.08	0.017	0.056
EtFOSE	0.012	0.04	0.010	0.034

Bovine plasma was chosen as the matrix match because it has relatively low concentrations of PFCs compared to human plasma. These values are comparable to other limits of detections and quantification determined in the literature by methods using online SPE with LC-MS for plasma (LOD of 0.009 to 0.070 ng/mL depending on analyte (Gosetti et al., 2010)) and serum (LOD of 0.03 to 0.1 ng/mL (Mosch et al., 2010) and 0.002 to 0.05 ng/mL (Haug et al., 2009b) depending on analyte).

PFCAs are used as polymerization aids in the manufacturing of fluoropolymers such as Teflon®, and therefore, these polymers must be avoided in order to reduce chance of contamination of PFCs in samples (Martin et al., 2004). Parts containing these fluoropolymers such as tubing and seals in the LC-MS/MS system were replaced with polyetheretherketone or stainless steel, as applicable. To reduce the chance of contamination, a column was placed downstream of the LC aqueous pump head in order to trap any PFCs on the column so they did not enter the analytical column. Fluoropolymers can also be found in septa of vial lids, so septa made of silicone were used for samples and standard solutions to avoid contamination. For most analytes, background detection of PFCs in blanks was infrequent. When background levels of PFCs were detected, the concentrations were generally low i.e., below the LOQ. This observation indicates that the trap installed upstream of the LC analytical column worked well at preventing PFCs from the LC system to cause contamination in amounts that would interfere with the analysis.

It was not possible to replace all fluoropolymer containing parts of the LC-MS/MS system such as solvent bottle tubing, autosampler injection syringe plunger, and

frits in the MS. This may account for the low, but detectable background levels, which were generally below the LOQ, of PFCs observed in the tested samples. Because of this, the background levels of PFCs were quantified on each day of analysis by using solvent blanks spiked with internal standards in triplicate. The background concentrations were subtracted from all samples analyzed in that set of samples if background PFCs were above the LOD. Most analytes had non-detectable background concentrations for about three quarters of the tested samples. The largest blank background value subtracted from the smallest measured peak which resulted in a peak over the LOQ occurred for PFHpA (0.077 ng/mL background and 0.15 ng/mL measured peak resulted in a final concentration of 0.073 ng/mL).

Due to their surfactant properties, certain PFCs can adsorb to surfaces such as glass (Holm et al., 2004). Samples and standard solutions were prepared and stored in polypropylene vials in order to avoid this adsorption and subsequent loss of PFCs such as PFOS.

Matrix-matched calibration curves can be done by spiking the matrix (serum, plasma, or whole blood) with a range of PFC concentrations, and have the advantage of adding matrix effects to the calibration curve. Matrix-matched calibration curves for analysis of PFCs in blood are typically done in bovine blood, as it is difficult to find human blood that does not contain PFCs (Haug et al., 2009b; Lien et al., 2011). However, if the matrix effects are small enough that non matrix-matched calibration curves perform in the same manner as matrix-matched calibration curves, matrix-matched calibration curves are not necessary.

Solvent calibration solutions were used for these analyses. Solvent calibration curves do not account for matrix effects, but the effects of matrix components would be accounted for by the use of internal standards in all samples. The internal standards were added to the blood samples before extraction; these internal standards underwent matrix effects and possible loss during the extraction procedure in the same manner that the native analytes did. Isotopic internal standards were not commercially available for all analytes. Slightly different matrix effects might have been experienced by analytes with internal standards that were not isotopes of that analyte (e.g. PFPA). It is not expected that different matrix effects by non-isotopic internal standards affected the results significantly as the method validation results were satisfactory, as discussed further in this section. Because internal standards were added before extraction, any loss of analyte during extraction procedure would be accounted for by proportional loss of the internal standard. Therefore, solvent calibration curves are accurate for use in determining the concentrations of analytes in samples. Good linearity was observed (R^2 >0.98) for all calibration curves.

Eight point calibration curves from 0.05-50 ng/mL were constructed in both solvent and in bovine plasma on three different days. The slopes of the standard addition bovine plasma calibration curves were compared to the slopes of the solvent calibration curves for each analyte (paired *t*-test, n = 3). The slopes for 16 of the PFCs were not significantly different for the solvent calibration curves compared to the matrix-matched bovine plasma calibration curves over the range 0.05-50 ng/mL. However, for PFOA the slopes were significantly different over the range 0.05-50 ng/mL (p = 0.02). Omitting the calibration point at 50 ng/mL changed the slope slightly so that the p-value was >0.05.

Therefore, for PFOA, no significant difference was observed between the solvent calibration curves and matrix-matched bovine plasma calibration curves over the range 0.05-20 ng/mL. Because of this, all samples were analyzed using non matrix-matched calibration curves of 0.05-20 ng/mL for PFOA and 0.05-50 ng/mL for all other analytes. No samples contained concentrations that exceeded the upper limits of the calibration curves for any analyte.

Recoveries were determined by spiking bovine plasma at concentrations of 1.0, 5.0, 20, and 50 ng/mL for 16 PFCs. Because the highest calibration point for PFOA was 20 ng/mL, the recoveries for PFOA were determined from plasma spiked at 0.5, 1.0, 5.0, and 20 ng/mL. Recoveries were calculated as $C_{observed}/C_{spike}$, where $C_{observed}$ is the difference between the measured concentration in the spiked sample and the measured concentration in the native sample and C_{spike} is the spiked concentration (Gosetti et al., 2010). When background levels of PFCs were measured in blanks, those mean values from three blanks were subtracted from all measured concentrations. The total mean recoveries are displayed in Table 2.4. The native PFC concentrations in the samples used for percent recoveries varied by analyte and ranged from 96 to 116%. The coefficient of variance ranged from 6.0 to 13%. These results are similar to what has been seen for recoveries in other studies (84 to 112% recovery (Mosch et al., 2010), 97.0 to 106% recovery with 3.4 to 19% relative standard deviation (Olsen et al., 2012), and 91.1 to 102% recovery with 13.9 to 25.2% standard deviation (Chan et al., 2011), depending on the analyte).

Table 2.4. Mean percent recoveries and percent coefficient of variances for 17 PFCs.

Analyte	Total Mean Recovery (%)	Coefficient of Variance (%)
PFPA	97	9.6
PFHxA	106	7.5
PFHpA	96	8.7
PFOA	103	6.7
PFNA	105	9.1
PFDA	106	6.5
PFUA	106	7.2
PFBS	104	7.2
PFHxS	98	6.3
PFOS	105	13
PFDS	102	13
8:2 FTUCA	116	12
FOSA	107	6.4
MeFOSA	107	6.1
EtFOSA	101	6.0
MeFOSE	97	6.4
EtFOSE	106	7.8

Interday and intraday precision were determined by spiking four human plasma samples at two concentrations (0.5 ng/mL and 2.0 ng/mL) in triplicate over three days. Interday precision was calculated by finding the percent coefficient of variances for the

measured analyte values for three days at each spike concentration. Intraday precision was calculated by finding the percent coefficient of variances for the measured analyte values of each day at each spike concentration (Table 2.5). The interday precision ranged from 5.3 to 16% and 3.8 to 14% for 0.5 ng/mL and 2.0 ng/mL, respectively. The intraday precision ranged from 3.6 to 14% and 3.7 to 7.4% for 0.5 ng/mL and 2.0 ng/mL, respectively. These results are similar to what has been previously observed for precision (5 to 18% coefficient of variance for interday precision and 1 to 22% coefficient of variance for intraday precision depending on analyte for 0.4 ng/mL and 2.0 ng/mL PFC spike concentrations (Mosch et al., 2010)).

Table 2.5. Interday and intraday precision values for spiked human plasma.

Analyte	Interday Precision (% Coefficient of Variance)		Intraday Precision (% Coefficient of Variance)	
	0.5 ng/mL	2.0 ng/mL	0.5 ng/mL	2.0 ng/mL
PFPA	12	7.3	6.6	3.8
PFHxA	16	6.4	14	5.7
PFHpA	15	8.5	6.6	6.5
PFOA	7.8	4.4	5.7	3.9
PFNA	8.6	5.7	5.2	4.5
PFDA	6.4	5.2	6.0	4.7
PFUA	5.3	3.8	3.6	3.7
PFBS	9.8	7.0	8.4	6.0
PFHxS	10	6.6	9.8	6.8
PFOS	12	8.8	8.6	7.0
PFDS	14	14	9.8	5.3
8:2 FTUCA	7.7	7.5	6.8	7.4
FOSA	5.3	4.6	4.4	3.3
MeFOSE	7.3	7.1	6.4	4.5
MeFOSA	6.6	6.1	5.6	5.2
EtFOSE	7.5	5.0	5.7	4.2
EtFOSA	6.9	7.2	4.7	4.2

Sodium azide is commonly added to biological solutions in order to prevent microbial growth as it is a metabolic inhibitor (Stone et al., 2010) and sodium azide was added to the CHILD plasma samples. In order to determine whether the addition of sodium azide interfered with the analysis method for this project, 11 matched CHILD plasma samples were measured with the absence or presence of sodium azide (ca. 0.2 μg/mL). No significant difference in PFC concentration was found between samples with the absence of sodium azide and samples with the presence of sodium azide (paired *t*-test).

The effect of storage temperature on human plasma samples was investigated by comparing the measuring the concentrations of PFCs in a sample that had been stored at 4^{o}C versus -20^{o}C. After plasma was collected from the participant, the sample was separated into two aliquots which were stored separately at the two temperatures. The aliquots were analyzed in triplicate for each temperature. For 16 of the 17 analytes the measured concentrations were not significantly different between samples stored at 4^{o}C and -20^{o}C (paired *t*-test, $p > 0.05$). However, the concentrations of PFPA were significantly different at the two temperatures ($p = 0.02$; the median concentration at 4^{o}C was 11% lower than the mean concentration at -20^{o}C). The difference in concentration at different temperatures may have been due to the slightly high interday precision for PFPA (Table 2.5) because the concentrations were measured over three days. Overall, it was concluded that storage temperature between 4^{o}C and -20^{o}C did not affect the concentrations of PFCs in human plasma samples. Blood samples were generally stored at approximately -20^{o}C until use in order to prevent any biological transformation or

degradation of PFCs; however some samples were stored at 4^{o}C overnight when thawing for aliquoting.

The certificate of analysis for 8:2 FTUCA states that this analyte may form methoxy derivatives when stored in methanol (Wellington Laboratories, 2012). The commercially available stock solution was stored in isopropanol to limit the formation of methoxy derivatives. Because all standard solutions were prepared in methanol, the stability of this compound in methanol was tested. Separate diluted stock solutions of 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ in isopropanol were prepared. On Day 1 of the stability testing, a 100 pg/uL solution containing 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ from the diluted stock solutions was prepared in methanol. A four point calibration curve ranging from 10-200 pg/uL was prepared using PFDA-$^{13}C_2$ as the internal standard as 8:2 FTUCA-$^{13}C_2$ needed to be quantified. PFDA-$^{13}C_2$ was chosen as the internal standard because it was similar in structure to 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ as they each contain ten carbons and a carboxylic acid functional group.

The stability of 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ was tested periodically over 96 days. On each day of testing, a calibration curve was prepared from the diluted stock solutions in isopropanol. The calibration curve was analyzed once and the 100 pg/uL solution of 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ that was prepared on Day 1 was analyzed in triplicate. There was no significant difference between the concentrations of 8:2 FTUCA or 8:2 FTUCA-$^{13}C_2$ from Day 1 to Day 96 (paired *t*-test). Therefore, 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ solutions were considered to be stable over that period of time. 8:2 FTUCA and 8:2 FTUCA-$^{13}C_2$ solutions prepared in methanol were only used if they were prepared within the previous 96 days.

2.3.2. Concentrations of PFCs in Plasma

The mean and median concentrations measured in 414 prenatal maternal and 247 one year maternal plasma samples are displayed in Table 2.6 and Table 2.7. As expected, PFOS and PFOA were among the analytes with the highest mean and median concentrations out of the 17 PFCs analyzed. A chromatogram representing a typical maternal plasma sample is shown in Figure 2.4.

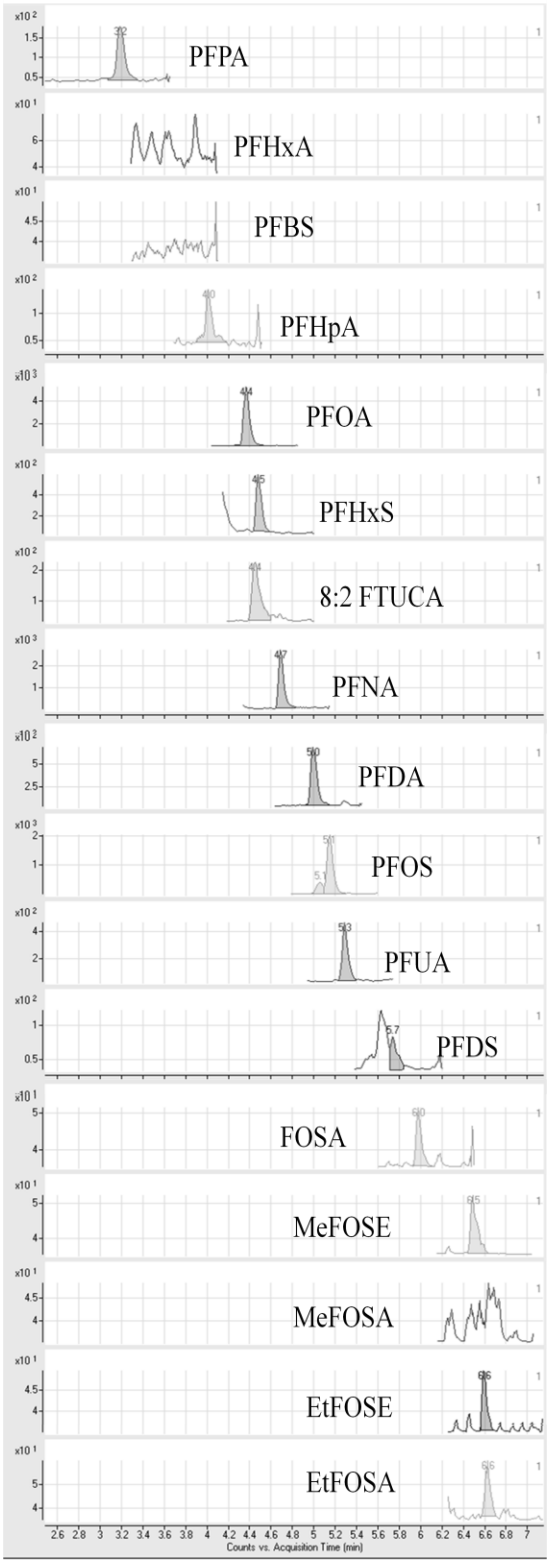
Table 2.6. Concentrations (ng/mL) and summary statistics of PFCs of the current study, in prenatal maternal plasma (n = 414). LOQ values in Table 2.3.

Analyte	Mean	Median	Range	95th Percentile	Percent above the LOQ
PFPA	0.48	0.46	<LOQ-2.2	0.96	71
PFHxA	<LOQ	<LOQ	<LOQ-0.25	< LOQ	0.48
PFHpA	<LOQ	<LOQ	<LOQ-0.31	0.10	11
PFOA	1.1	0.89	0.16-7.1	2.2	100
PFNA	0.44	0.37	<LOQ-4.0	0.88	96
PFDA	0.15	0.13	<LOQ-1.4	0.36	94
PFUA	0.091	0.069	<LOQ-0.68	0.27	85
PFBS	<LOQ	<LOQ	<LOQ	< LOQ	0.0
PFHxS	0.73	0.44	<LOQ-24	2.2	89
PFOS	2.6	2.2	0.18-21	5.4	100
PFDS	<LOQ	<LOQ	<LOQ-0.34	0.069	21
8:2 FTUCA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
FOSA	<LOQ	<LOQ	<LOQ-0.24	<LOQ	0.24
MeFOSE	<LOQ	<LOQ	<LOQ-0.2	<LOQ	0.24
MeFOSA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
EtFOSE	<LOQ	<LOQ	<LOQ -0.084	<LOQ	1.0
EtFOSA	<LOQ	<LOQ	<LOQ -0.17	<LOQ	1.2

Table 2.7. Concentrations (ng/mL) and summary statistics of PFCs in maternal plasma of the current study, one year after giving birth (n = 247). LOQ values in Table 2.3.

Analyte	Mean	Median	Range	95th Percentile	Percent above the LOQ
PFPA	0.90	0.81	<LOQ-2.5	1.8	95
PFHxA	0.009	<LOQ	<LOQ-0.23	<LOQ	0.40
PFHpA	<LOQ	<LOQ	<LOQ-0.24	0.11	11
PFOA	0.66	0.55	0.15-2.8	1.6	100
PFNA	0.35	0.33	<LOQ-2.3	0.72	84
PFDA	0.13	0.12	<LOQ-1.3	0.29	82
PFUA	0.090	0.071	<LOQ-1.0	0.24	81
PFBS	<LOQ	<LOQ	<LOQ	<LOQ	0.0
PFHxS	0.68	0.40	<LOQ-16	2.4	98
PFOS	2.2	1.8	0.22-20	4.7	100
PFDS	<LOQ	<LOQ	<LOQ-0.19	0.054	8.5
8:2 FTUCA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
FOSA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
MeFOSE	<LOQ	<LOQ	<LOQ	<LOQ	0.0
MeFOSA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
EtFOSE	<LOQ	<LOQ	<LOQ-0.072	<LOQ	0.81
EtFOSA	<LOQ	<LOQ	<LOQ-0.13	<LOQ	2.0

Figure 2.4. Chromatogram of a typical prenatal maternal plasma sample (sample identification number (ID) 40600).



The concentrations found in prenatal samples were compared to values from other studies from various sampling dates and countries which are shown in Table 2.8. PFC concentrations in plasma and serum have been measured with a one to one ratio in human blood regardless of concentration (Ehresman et al., 2007) and therefore, plasma and serum results are comparative. This is likely because PFCs bind to albumin (Bischel et al., 2011; Y. Chen & Guo, 2009; Karrman et al., 2006; Li et al., 2010; MacManus-Spencer et al., 2010), and both serum and plasma contain albumin. The difference between serum and plasma is the absence of clotting factors in serum (Campbell, 1996), and therefore, albumin levels are not affected in the separation between serum and plasma. Numerous studies have used PFC concentrations in plasma and serum as comparative (Fromme et al., 2009; Olsen et al., 2012; Reiner et al., 2011; Vestergren & Cousins, 2009).

The median PFOS concentration found in the prenatal maternal plasma in this study was lower than any other study to which it was compared. The levels of PFOS in these studies are shown in Table 2.8. These studies follow a decreasing trend in concentration with sampling time since around year 2000, which is consistent with what has been observed in the U.S. (Kato et al., 2011; Olsen et al., 2012; Spliethoff et al., 2008; M. Wang et al., 2011), Norway (Haug et al., 2009a), and Sweden (Glynn et al., 2012). This decreasing trend is most likely due to the voluntary phase-out of PFOS product manufacturing around year 2000. The median prenatal PFOS concentration from this study was similar (within 1.5 fold) to that reported from Korea and China in 2008 and 2009 (S. Kim et al., 2011; Liu et al., 2011). However, the median PFOS concentration of the current study was quite different (within 8.5 fold) than the other

Canadian studies for samples taken from 2004 to 2006 (Chan et al., 2011; Hamm et al., 2010; Monroy et al., 2008). This observation indicates a possible decrease in exposure to PFOS to people from Winnipeg, Manitoba in 2010 and 2011 compared to people from Hamilton, Ontario and Edmonton, Alberta in 2004, 2005, and 2006. It is unknown whether the geographical or temporal difference is the cause of the lower concentrations in samples from this study, but it is believed to be a temporal change as that has been observed from samples around the world (Glynn et al., 2012; Haug et al., 2009a; Olsen et al., 2012).

Table 2.8. Mean or median concentrations (ng/mL) of commonly measured PFCS in prenatal maternal blood from various studies and locations.

Country, Sampling Year(s)	Plasma or Serum, Median or Mean	Analyte					
		PFOA	PFNA	PFDA	PFUA	PFHxS	PFOS
U.S., 2001-2006[a]	Serum, geometric mean	2.39	-	-	-	-	12.2
Japan, 2002-2005[b]	Serum, median	1.3	-	-	-	-	5.2
Japan, 2003[c]	Serum, mean	<0.5	-	-	-	-	8.9
Germany, 2003[d]	Plasma, mean	2.7	-	-	-	-	13.1
Norway, 2003-2004[e]	Plasma, median	2.2	-	-	-	-	13.0
Canada, 2004-2005[f]	Serum, mean	2.54	0.86	-	-	4.13	18.3
Canada, 2005-2006[g]	Serum, mean	2.1	-	-	-	2.1	9.0
Canada, 2005-2006[h]	Serum, geometric mean	1.35	-	-	-	1.08	7.39
South Africa, 2005-2006[i]	Serum, mean	1.3	0.5	-	-	0.5	1.6
Korea, 2007[j]	Serum, mean	1.6	0.79	0.36	1.6	0.89	5.6

Country, Sampling Year(s)	Plasma or Serum, Median or Mean	Analyte					
		PFOA	PFNA	PFDA	PFUA	PFHxS	PFOS
Norway, 2007-2008[k]	Plasma, median	1.12	0.34	0.07	0.16	0.28	4.99
Canada, 2007-2008[l]	Serum, mean	1.8	0.9	0.4	-	1.7	5.5
Germany, 2007-2009[m]	Plasma, mean	2.6	2.8	<0.4	-	0.6	3.5
Korea, 2008-2009[n]	Serum, mean	1.46	0.44	0.31	0.60	0.55	2.93
China, 2009[o]	Serum, mean	1.66	0.55	0.58	0.56	0.08	3.18
Canada, 2010-2011 (this study)	Plasma, median	0.89	0.37	0.13	0.069	0.44	2.2

Values of "-" were not analyzed. Values with "<" were below the detection limit of the analysis.

a. Woodruff et al., 2011

b. Okada et al., 2012

c. Inoue et al., 2004

d. Midasch et al., 2007

e. Whitworth et al., 2012

f. Monroy et al., 2008

g. Hamm et al., 2010

h. Chan et al., 2011

i. Hanssen et al., 2010

j. S. K. Kim et al., 2011

k. Gutzkow et al., 2012

l. Beesoon et al., 2011

m. Fromme et al., 2010

n. S. Kim et al., 2011

o. Liu et al., 2011

The median PFOA level for this study was lower than that of other studies (Table 2.8), but was always within the same magnitude of other studies in various countries including Canada. Decreasing temporal trends of PFOA have not been observed as widely as PFOS, but it has been observed that levels of PFOA in samples from the U.S. decreased after the year 2000 for infant blood spots (Spliethoff et al., 2008) and adult samples (Glynn et al., 2012; Olsen et al., 2012). This is most likely due to the stewardship program developed in the U.S. in 2006. Eight major manufacturers of PFOA have drastically reduced their PFOA production and aim to eliminate PFOA production by 2015 (U.S. Environmental Protection Agency (EPA), 2012).

Decreasing levels of FOSA and PFDS have also been observed in one study (Glynn et al., 2012), which may explain why the majority of samples in this study had concentrations below the LOQ for these analytes. Low or non-detectible levels of PFBS, PFHxA, PFHpA, PFDS in human plasma (Olsen et al., 2012) and serum (Haug et al., 2009b) have been observed in the literature. The low levels of 8:2 FTUCA, FOSAs, and FOSEs in this study are not surprising as these compounds are subject to biotransformation (Brandsma et al., 2011; Martin et al., 2005; Tomy et al., 2004; Xu et al., 2004) and the production of FOSEs has been phased out by 3M (Houde et al., 2006). Additionally, 8:2 FTCA was monitored in all plasma samples using the transition 477 → 363.1. Monitoring of 8:2 FTCA showed no presence of this analyte in plasma samples. The absence of 8:2 FTCA in plasma was not surprising as 8:2 FTCA is subject to biotransformation (Butt et al., 2010; Martin et al., 2005).

Median concentrations of PFNA, PFDA, and PFHxS from this study are similar to concentrations found in other studies, especially those which samples were taken more recently (i.e. sampled since 2007). Not many studies shown in Table 2.8 analyzed samples for PFUA, but those which did are within two magnitudes of the median concentration from this study (Gutzkow et al., 2012; S. K. Kim et al., 2011; S. Kim et al., 2011; Liu et al., 2011). A representative study of adults in the U.S. found that levels of PFHxS and PFNA had declined from the year 2000 to 2010 (Olsen et al., 2012), which is consistent with the levels seen here. However, levels of PFHxS in Swedish samples have shown an increasing temporal trend from 1996 to 2010 (Glynn et al., 2012), demonstrating that exposure may differ geographically.

Interestingly, PFPA was one of the highest measured analytes in the samples from this study. This suggests that this short chain-length carboxylic acid may have been used as a replacement for PFOA, as the production of PFOA has been reduced since 2002 (Prevedouros et al., 2006) and shorter chain-length carboxylic acids are less bioaccumulative than the longer chain-length carboxylic acids (Conder et al., 2008). The half-life of PFPA in humans has not been established, but the half-life of the four carbon chained PFCA (perfluorobutanoic acid, PFBA) is estimated as 75 days in humans (Chang et al., 2008) which is significantly less than the longer carbon chained PFOA which has a half-life estimated as 3.8 to 22 years (Burris, 2002; Glynn et al., 2012; Olsen et al., 2007; Spliethoff et al., 2008). Additionally, the half-life of PFHxA in humans has been speculated to be less than four weeks (Nilsson et al., 2010). Because the perfluroalkyl chain length of PFPA is more similar to PFBA or PFHxA than PFOA, it is likely that the half-life of PFPA is closer to the values of PFBA or PFHxA. Therefore, it is expected that

the half-life of PFPA would be on the order of weeks rather than years. Because the half-life of PFPA is expected to be relatively short, PFPA concentrations in plasma most likely represent recent exposure to the compound.

Relatively high PFPA concentrations have not been measured in human blood from other studies. A representative study of adults in the U.S. with sampling years of 2000-2001, 2006, and 2010 showed that the majority of samples were below the lower LOQ (0.025 ng/mL) for PFPA (Olsen et al., 2012). A study which measured PFPA in eight Swedish adults working as ski wax technicians in 2007 also found that PFPA concentrations were mostly below the LOD (0.06 ng/mL) (Nilsson et al., 2010). Additionally, a Norwegian study on archived serum samples from 1976 to 2007 found that most samples had PFPA concentrations close to the LOQ (0.05 ng/mL) (Haug et al., 2009a). The high levels of PFPA observed in the participants of this study may indicate more exposure to newer items containing the shorter chain-length PFC than participants from other studies or that Canada is using more PFPA than other countries.

PFPA has recently been found in bodies of water around the world, which may account for migration and exposure of this analyte. It has been noted that shorter chain-length PFCs such as PFPA may have increased migration potential (Boiteux et al., 2012). On average, PFPA was measured as the third most abundant PFC in the Northwest Pacific Ocean and the most abundant in the Arctic Ocean and the Bering Sea out of 14 measured PFCs (Cai et al., 2012). PFPA has also recently been found in treated water in France (Boiteux et al., 2012) and river water and treated water in Germany (Wilhelm et al., 2010). Therefore, waterways may act as a source of transport for PFPA. Studies have concluded that drinking water is a direct source of PFCs to humans (D'Hollander et al.,

2010; Egeghy & Lorber, 2011; Llorca et al., 2012), especially the shorter chain-length PFCs (Vestergren et al., 2012).

The mean and median concentrations measured from the plasma of 50 cord blood samples are displayed in Table 2.9. As expected, PFOS and PFOA had the highest mean and median concentrations out of the 17 PFCs analyzed, which is consistent with other studies (Table 1.3). In general, PFC concentrations in cord blood were similar to other recent studies (Beesoon et al., 2011; Fromme et al., 2010; S. Kim et al., 2011), except for PFPA, which to our knowledge has not been analyzed in cord blood before. The presence of PFCs in cord blood shows that there was prenatal transfer of PFCs from mother to fetus.

Table 2.9. Concentrations (ng/mL) and summary statistics of PFCs in cord blood of this study (n = 50). LOQ values in Table 2.3.

Analyte	Mean	Median	Range	95th Percentile	Percent above the LOQ
PFPA	0.52	0.52	<LOQ-1.1	0.84	82
PFHxA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
PFHpA	<LOQ	<LOQ	<LOQ-0.13	0.12	34
PFOA	0.68	0.58	0.19-1.7	1.6	100
PFNA	<LOQ	<LOQ	<LOQ-0.78	0.47	34
PFDA	0.053	0.053	<LOQ-0.27	0.19	68
PFUA	0.034	<LOQ	<LOQ-0.20	0.15	50
PFBS	<LOQ	<LOQ	<LOQ	<LOQ	0.0
PFHxS	0.38	0.26	<LOQ-3.7	1.2	82
PFOS	0.96	0.80	0.15-2.7	2.4	100
PFDS	<LOQ	<LOQ	<LOQ-0.066	<LOQ	4.0
8:2 FTUCA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
FOSA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
MeFOSE	<LOQ	<LOQ	<LOQ	<LOQ	0.0
MeFOSA	<LOQ	<LOQ	<LOQ	<LOQ	0.0
EtFOSE	<LOQ	<LOQ	<LOQ	<LOQ	0.0
EtFOSA	<LOQ	<LOQ	<LOQ-0.078	<LOQ	4.0

On one occasion, the baseline of PFPA in the LC-MS/MS chromatogram was unusually high, and as a result, four cord blood samples had PFPA values that had S/N <3. In order to re-quantitate, the remaining sample in the vials were diluted to ensure there was enough sample to inject into the LC-MS/MS system, then samples were re-analyzed for PFPA. The re-analyzed diluted samples all had S/N >3 for PFPA. Ten other plasma samples were diluted and re-analyzed in the same manner and the PFPA values were compared between the standard sample preparation and the diluted sample. No significant difference was found in the measurement of PFPA between standard sample preparation and diluted samples (paired *t*-test). Therefore, the diluted samples were used for PFPA values for those four samples.

Adult plasma is advantageous over cord blood for analysis because it is easier to collect. Samples from prenatal mothers can be collected at the convenience of the collector and of the participant where as cord blood samples have to be collected at the time of birth. Additionally, the volume of cord blood that can be collected is much smaller than what can be collected from an adult. Many other studies have used prenatal maternal samples as surrogate samples for cord blood to investigate infant characteristics (Stein et al., 2009; Whitworth et al., 2012; Hamm et al., 2010; Fei et al., 2008). Therefore, the number of maternal samples collected in this study was much higher than the number of cord blood samples collected.

The transfer efficiency (TE) of PFCs in maternal plasma to cord blood plasma is expressed by the ratio of cord blood to maternal blood. The TEs in this study are comparable to other recent studies where data is available (Table 2.10). For PFPA, no data is available to compare to. The ratio of PFPA is 1.0, which is higher than any other

PFC in this data set. It has previously been observed that for PFCAs, the TE decreased with every unit increase of perfluoroalkyl chain-length for PFOA, PFNA, PFDA, and PFUA (S. K. Kim et al., 2011). This trend was observed elsewhere for PFOA, PFNA, and PFDA, but the TEs increased for PFUA and perfluorotridecanoic acid (PFTrDA) (Liu et al., 2011). It was noted that the TE results of PFTrDA should be evaluated cautiously as they were the first TE measured for that compound (Liu et al., 2011). Similarly, the TEs from another study follow a decreasing pattern with every chain-length increase for PFOA, PFNA, and PFDA, and for PFHxS and PFOS (Beesoon et al., 2011). These results agree with what was found in this study, in that the longer chain-length PFCA and PFSA have the lowest TEs in their functional group set (Table 2.11). Therefore, the highest TE for the shortest chain-length PFCA is not surprising.

Table 2.10. Median or mean TEs of PFCs in maternal blood to cord blood for various recent studies and this study. Values of "-" were not evaluated.

Study Location (Plasma or Serum, Median or Mean)	Analyte				
	PFPA	PFOA	PFDA	PFHxS	PFOS
Canada, this study (Plasma, median)	1.0	0.80	0.39	0.55	0.39
Canada[a] (Serum, mean)	-	-	-	-	0.45
Canada[b] (Serum, median)	-	0.61	0.23	0.38	0.30
China[c] (Serum, median)	-	0.89	0.39	0.73	0.54
Germany[d] (Plasma, mean)	-	0.7	-	-	0.3
Korea[e] (Serum, mean)	-	0.69	0.33	0.64	0.36
Norway[f] (Plasma, median approximated from a graph)	-	0.8	-	0.7	0.3
South Africa[g] (Serum, mean)	-	0.71	-	0.48	0.45

a. Monroy et al., 2008

b. Beesoon et al., 2011

c. Liu et al., 2011

d. Fromme et al., 2010

e. S. K. Kim et al., 2011

f. Gutzkow et al., 2012

g. Hanssen et al., 2010

Table 2.11. Median TEs of PFCs in maternal blood to cord blood for this study in relation to their functional group and carbon chain length.

	PFCA Analyte (Number of Carbons)			PFSA Analyte (Number of Carbons)	
	PFPA (C5)	PFOA (C8)	PFDA (C10)	PFHxS (C6)	PFOS (C8)
TE	1.0	0.80	0.39	0.55	0.39

When maternal samples were taken at different times during pregnancy, it was found that the levels of PFCs generally decline as pregnancy progresses (Fei et al., 2007; Glynn et al., 2012). As noted in a previous study (Liu et al., 2011), this may affect TEs, and caution should be taken when comparing TEs from blood sampled at different time points. The recent studies that were used as a comparison to this work for these ratios sampled the maternal blood in a one week span of time around the delivery, except for the study conducted by Beesoon et al. (2011) in which the samples were taken during the first trimester. The maternal samples from our study were taken during the second trimester, which therefore may make the TEs slightly lower than they would have been if these samples were taken around the time of delivery. A study of 19 Swedish women found a higher correlation between PFCs in cord and maternal blood during the third trimester compared to the first trimester (Glynn et al., 2012), showing that samples taken later on in pregnancy may be better representations of infant levels.

2.3.3. Distributions and Correlations between PFCs in Plasma

The Spearman rank correlation coefficients between PFCs in maternal blood and cord blood from this work and various studies are shown in Table 2.12. Spearman rank coefficients indicate how strongly the analytes are correlated between the two plasma sample sets for non-parametric data. Spearman rank was ideal for this data because of the large n values and because the data was not normally distributed. The results from this study are similar to other studies. Except for PFPA, the correlations are strong ($r > 0.66$) for all measurable PFCs from the various studies. The high Spearman rank values indicate there was a strong relationship between cord and maternal blood. Because of this strong relationship, maternal blood is a suitable surrogate for predicting infant blood PFC distributions. In this respect, maternal blood can be used in place of cord blood for correlations between infant characteristics and PFC concentrations such as developmental effects.

Table 2.12. Spearman rank correlation coefficients between maternal blood and cord blood. Values of "-" were not evaluated.

Study Location (Plasma or Serum)	Analyte				
	PFPA	PFOA	PFDA	PFHxS	PFOS
Canada (this study, plasma)	0.49	0.89	0.69	0.85	0.83
Canada[a] (serum)	-	0.63	-	-	0.81
Germany[b] (plasma)	-	0.94	-	0.89	0.89
Norway[c] (plasma)	-	0.82	-	0.70	0.74
South Africa[d] (serum)	-	0.67	-	0.77	0.88

a. Beesoon et al., 2011
b. Fromme et al., 2010
c. Gutzkow et al., 2012
d. Hanssen et al., 2010

The Spearman rank correlation for PFPA was lower than the other analytes between prenatal and cord blood plasma. The half-life of PFPA is likely on the order of weeks based on estimates of PFBA and PFHxA (Chang et al., 2008; Nilsson et al., 2010), as noted previously in section 2.3.2. Therefore, the measured PFPA concentrations are expected to be mostly representative of recent exposure, and maternal PFPA may not be highly correlated with cord blood PFPA, which may have already crossed the placenta.

The correlations among different PFCs in prenatal maternal plasma were evaluated by calculating the Spearman rank correlation coefficients (Table 2.13). The results are similar to what other studies have found in that correlations among various PFCs were correlated to each other in pregnant women (Hanssen et al., 2010; S. K. Kim et al., 2011) and adults (Hanssen et al., 2010; Haug et al., 2009a; M. Wang et al., 2011). The highest correlations in the current study were found within the eight to eleven carbon chained PFCAs, with 0.77 for PFNA and PFDA, 0.64 for PFOA and PFNA, and 0.62 for PFDA and PFUA. This observation indicates that these compounds are likely coming from the same or similar sources. The production of ammonium perfluorooctanoate and ammonium perfluorononanoate gives off emissions of the intended eight to nine carbon-length PFCs, but also the ten to thirteen carbon-length PFCs as impurities (Armitage et

al., 2009). This fact may explain why the longer chain-length PFCAs have high correlations to each other.

Table 2.13. Spearman rank coefficients for PFCs with median values over the LOQ (Table 2.3) in prenatal maternal plasma. Boxes with "-" do not have significant correlation.

	PFPA	PFOA	PFHxS	PFNA	PFDA	PFOS	PFUA
PFPA		-	-	-	-	-	-
PFOA			0.52	0.64	0.46	0.52	0.16
PFHxS				0.28	0.20	0.48	0.15
PFNA					0.77	0.59	0.53
PFDA						0.55	0.62
PFOS							0.36
PFUA							

The Spearman rank correlation coefficients for maternal plasma one year after delivery are displayed in Table 2.14. As found with the prenatal samples, the highest correlations were found within the eight to eleven carbon chain PFCAs. In general, the correlation coefficients for postnatal plasma are lower than the prenatal plasma. This may be due to exposure to different items (e.g. new items for the baby) or preferential transfer of certain PFCs through the breast milk. Different transfer efficiencies from maternal blood to breast milk have been measured for different PFCs in previous studies. PFCs have been found to have preferential transfer of shorter chain-length over longer chain-

length analytes from maternal blood to breast milk (S. K. Kim et al., 2011). This could cause the proportions of PFCs in postnatal plasma to be different than in prenatal plasma. It would be expected that the correlations between PFCs would be different as postnatal plasma would contain a lower proportion of shorter chain-length PFCs. The results from this study show that there was a lower proportion of PFOA but unchanged proportions of PFNA, PFDA, and PFUA in postnatal plasma than prenatal plasma (Figure 2.5) which indicates that postnatal maternal transfer did occur. However, the proportion of PFOS decreased and PFPA increased in postnatal plasma compared to prenatal plasma, which is not indicative that postnatal transfer occurred in our samples. Therefore, it cannot be concluded solely from the concentrations of PFCs in plasma that postnatal transfer from breastfeeding occurred.

Figure 2.5. Median distributions of PFCs in maternal (prenatal n = 414, postnatal n = 247) and cord blood plasma (n = 50).

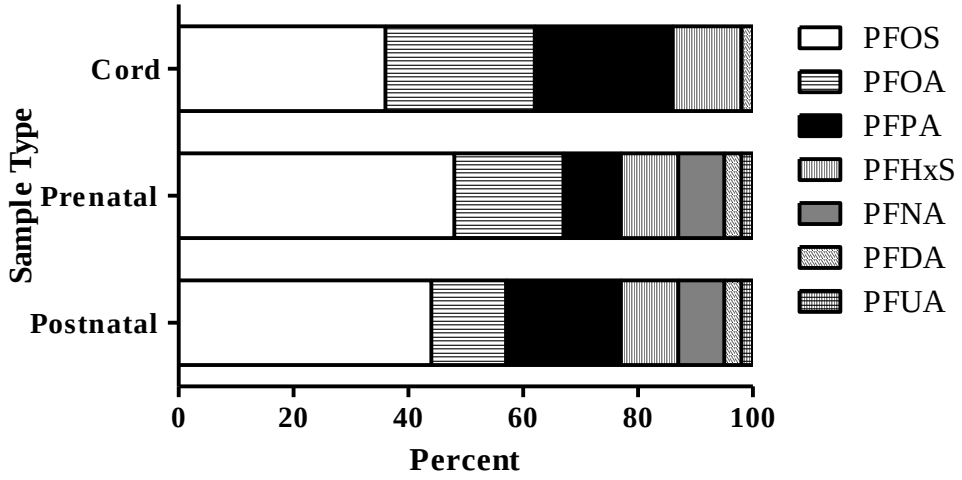


Table 2.14. Spearman rank coefficients for PFCs with median values over the LOQ (Table 2.3) in maternal plasma one year after delivery. Boxes with "-" do not have significant correlation.

	PFPA	PFOA	PFHxS	PFNA	PFDA	PFOS	PFUA
PFPA		-	-	-	-	-	-
PFOA			0.54	0.55	0.31	0.48	-
PFHxS				0.32	-	0.45	-
PFNA					0.56	0.55	0.49
PFDA						0.49	0.49
PFOS							0.40
PFUA							

In this study, the PFC distributions were different in prenatal maternal plasma than in cord blood plasma (Figure 2.5). The distribution difference between maternal and cord blood is most likely due to the differences in TEs for different PFCs (Table 2.11). The high TEs for PFOA and PFHxS explain why the proportions of those two analytes were higher in cord blood than in prenatal blood, and the low TEs for PFDA and PFOS explain why those two analytes had lower proportions in cord blood than prenatal blood (Figure 2.5). This result is in agreement with other studies that also found different PFC distributions between maternal and cord blood (Gutzkow et al., 2012; S. K, Kim et al., 2011).

No correlations between PFPA and any other PFC were significant for either time point. This may be due to different sources (i.e. newer items containing more short-

chained PFCs) and/or because the shorter half-life of the short-chained PFC may only indicate recent exposure, whereas the presence of longer-chain PFCs represents exposure integrated over longer periods of time.

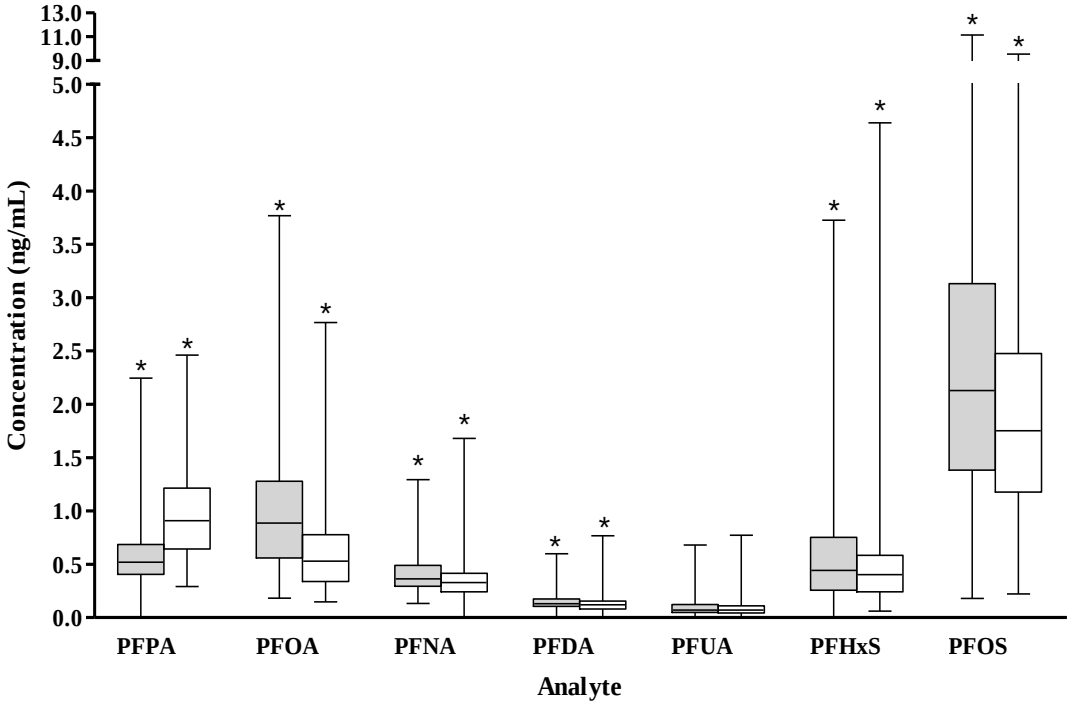
In maternal serum samples from South Africa, the Spearman rank correlation coefficients were 0.64 for PFOS and PFOA, 0.79 for PFOS and PFHxS, and 0.58 for PFOA and PFHxS (Hanssen et al., 2010). In Korea, maternal serum had Spearman rank coefficients of 0.76 for PFOA to PFNA, 0.46 for PFOA to PFHxS, 0.78 for PFNA to PFDA, 0.67 for PFNA to PFUA, and 0.78 for PFDA to PFUA (S. K. Kim et al., 2011). However, no significant correlations were found between PFOS and any of the other PFCs tested (S. K. Kim et al., 2011). In Norway, Spearman rank correlation coefficients of over 0.6 were found between PFOS, PFOA, and PFHxS, but the correlations with PFUA were lower (Gutzkow et al., 2012). The results from this study and other studies show that many PFCs are highly correlated with each other, regardless of location. This indicates that various PFCs are coming from similar or the same sources and perhaps in mixtures.

Matched prenatal and postnatal samples were compared to see if there was a difference in PFC concentrations between these two time points (Figure 2.6). Prenatal maternal plasma had significantly higher concentrations of PFOS, PFOA, PFHxS, PFNA, and PFDA than that in one year maternal plasma, but also had significantly lower levels of PFPA (Wilcoxon paired test). No significant difference was observed between the two time points for PFUA. The lower levels of the five PFCs above in postnatal maternal plasma may indicate loss through the breast milk and/or the loss through prenatal

maternal transfer, whereas the higher levels of PFPA suggests more recent exposure to this shorter chain-length PFC.

The higher levels of PFPA one year after delivery suggest that there is more exposure to this compound in the more recent samples. This may be due to the samples being sampled more recently (slightly over one year from the prenatal samples) and therefore, the subjects may have had more exposure to newer consumer products, which contained higher amounts PFPA than older consumer products. This may also be due to a potentially increased amount of consumer products in the home related to the birth of the baby.

Figure 2.6. Box and whisker plot of matched prenatal and postnatal samples (n = 161).



Whiskers show the minimum to maximum values. The bottom line of each box represents the 25th percentile, the middle line represents the 50th percentile, and the top line represents the 75th percentile. Grey boxes display prenatal samples and white boxes display postnatal samples. Boxes with "*" indicate the values between the prenatal and postnatal samples are significantly different for that analyte.

Similar results of lower PFC levels after pregnancy have been found in other studies. In the U.S., samples collected three to four months after delivery had lower concentrations than samples collected at two to seven weeks after delivery for PFOS, PFOA, and PFHxS for the 34 and 30 women analyzed at the two time points, respectively (von Ehrenstein et al., 2009). In Germany the median and mean levels of PFOS, PFOA, PFHxS, and PFNA were lower in mothers six months after delivery than during

pregnancy (Fromme et al., 2010). However, neither of these studies stated whether the decreases were significant. A Swedish study determined that the levels of PFOA were significantly lower three months after delivery than three weeks after delivery for 19 women, while the levels of PFOS and PFNA were not significantly different (Glynn et al., 2012). In Japan, the levels of PFOS and PFOA were significantly lower when sampled after delivery than during pregnancy (Okada et al., 2012). These lower levels of these PFCs after delivery than during pregnancy suggest that those PFCs are lost through maternal transfer.

The maternal transfer of PFCs included the transfer of PFCs to the infant, but was also thought to have included the loss of PFCs through the placenta and amniotic fluid. PFCs have been measured in amniotic fluid from pregnant women (median 0.4 ng/mL PFOS, 0.2 ng/mL PFOA (Stein et al., 2012); median 1.1 ng/mL PFOS (Jensen et al., 2012)) and the placentas of rats (Hinderliter et al., 2005). Therefore, it was expected that PFCs would be lost from the mother via amniotic fluid, placenta, and blood loss from the birth, as well as via transfer to the infant.

The Spearman rank correlation coefficients were calculated between PFCs at the two sampling time points, and were 0.33 for PFPA, 0.66 for PFOA, 0.73 for PFNA, 0.65 for PFDA, 0.76 for PFUA, 0.82 for PFHxS, and 0.82 for PFOS. The rank coefficient for PFPA was the lowest, which furthers the suggestion that this compound acted differently than the other PFCs perhaps due to a shorter half-life and use in recently produced consumer products. Samples from the U.S. were also evaluated at two time points (two to seven weeks and three to four months after delivery) and the Spearman rank coefficients were 0.84 for PFOS, 0.85 for PFOA, 0.80 for PFHxS, and 0.71 for PFNA (von

Ehrenstein et al., 2009). Even though these rank coefficients were calculated from different time points than this work, the coefficients are similar to what was found in this study. This demonstrates that the concentrations of PFCs are generally related between the two time points, suggesting similar exposure to the mothers during this time for most analytes.

2.3.4. Exposure and Trends of PFCs from Maternal and Home Characteristics

The exposure to PFCs associated with home characteristics and trends of PFCs with regards to maternal characteristics were evaluated by PCA, which was performed on the natural log transformations of the proportion of each PFC relative to the sum of analytes with median values over the LOQ. A large data set resulted from the combination of analytes (n = 7) and pre- and postnatal maternal plasma samples (n = 661). The resulting data set had thousands of data points, and therefore, PCA was an ideal way to reduce the data. PCA produces principal components (PCs), which are uncorrelated variables that can be used to reduce data (Hatcher, 1994). The first extracted PC was based on the largest amount of variance in the data. The second extracted PC was orthogonal to the first PC, and was based on the second largest amount of variance. This trend continues for each subsequent PC (Hatcher, 1994). PCs may reveal trends in data that were not obtainable before PCA.

Three PCs were retained based on the eigenvalue-one criterion (Hatcher, 1994). Because the eigenvalue for each of the three PCs had a value above one, the variance described by the PC was greater than the contribution of the variance from one variable. The percent of variability in the data accounted for was 24% from PC1, 20% from PC2,

and 17% from PC3. The loadings plot of the three PCs is shown in Figure 2.7. This plot shows the weight (expressed as a regression coefficient) of the proportion of each PFC on the PCs. Because it is difficult to interpret PCA results from a three-dimensional plot, the three-dimensional loadings plot was divided into three two-dimensional plots shown in Figure 2.8, Figure 2.9, and Figure 2.10.

Figure 2.7. Loadings plot of PC1, PC2, and PC3 for PFCs in maternal plasma.

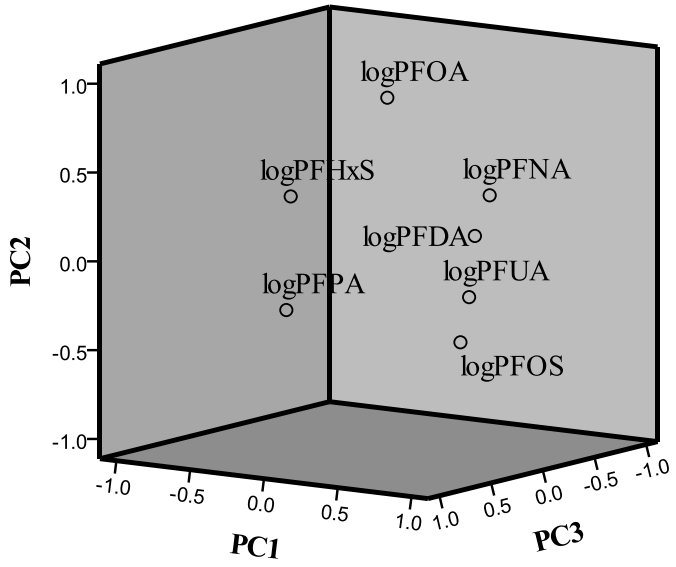


Figure 2.8. Loadings (top) and scores (bottom) plots of PC2 versus PC1.

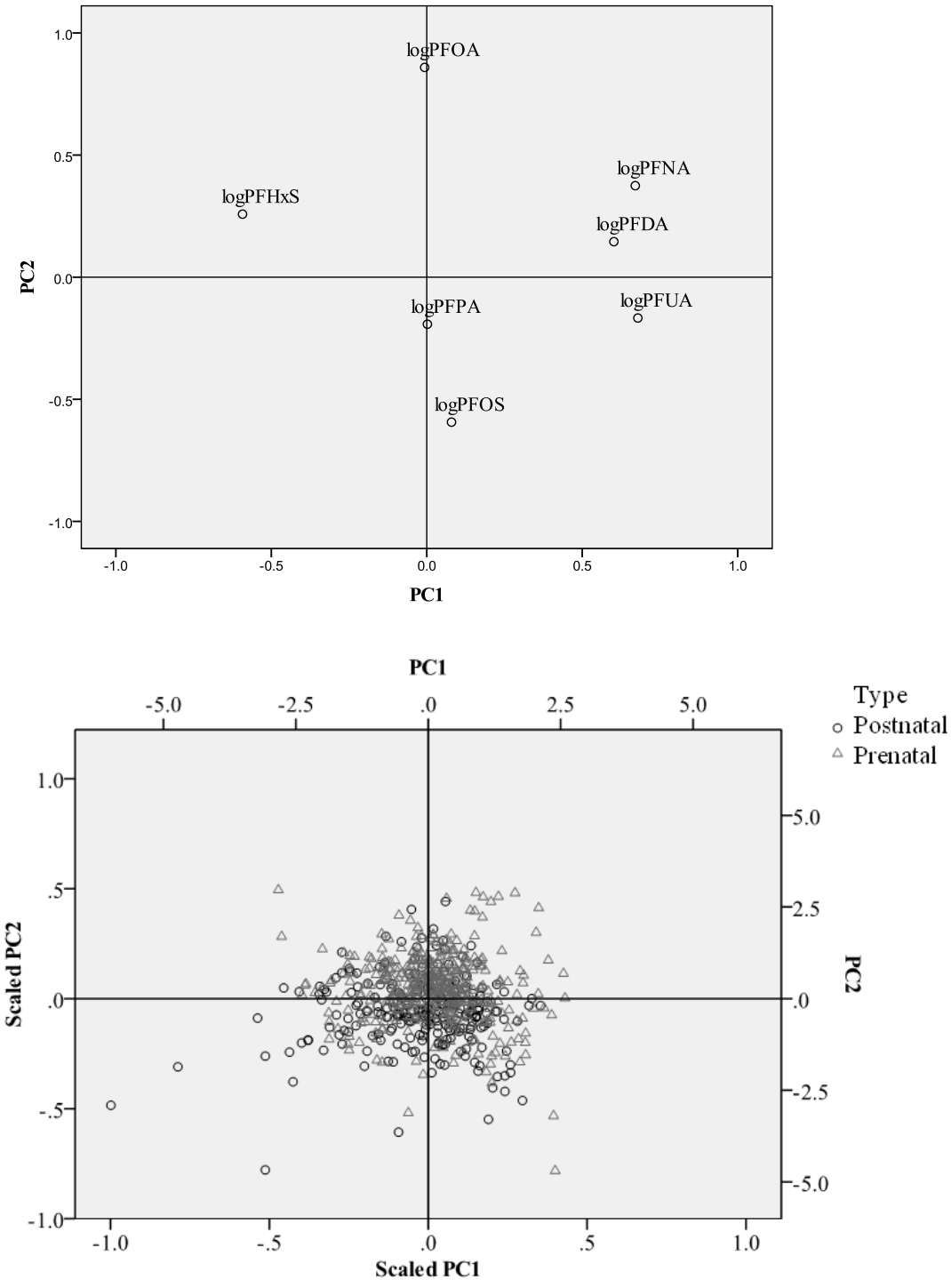


Figure 2.9. Loadings (top) and scores (bottom) plots of PC3 versus PC1.

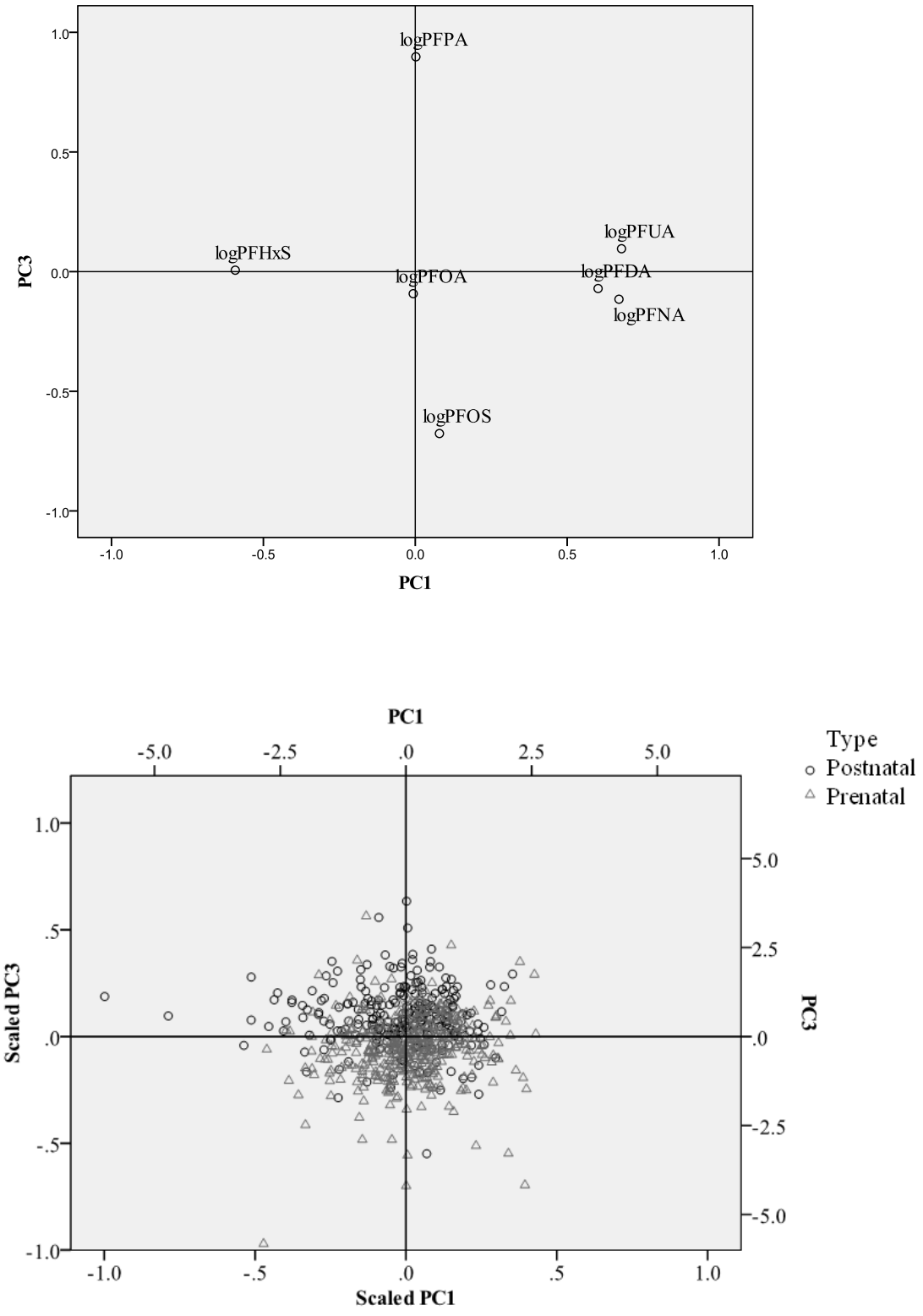
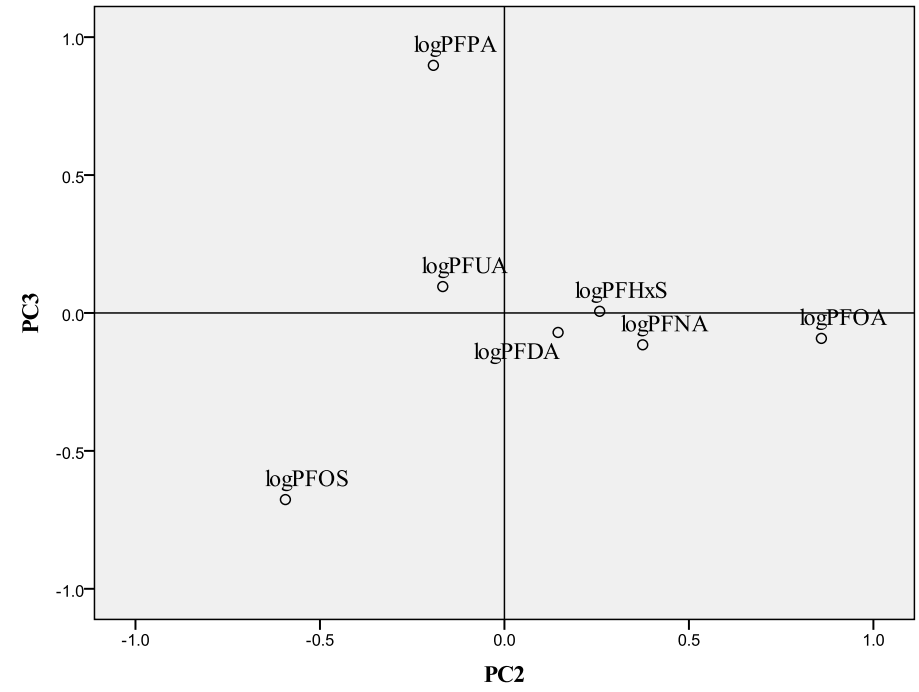
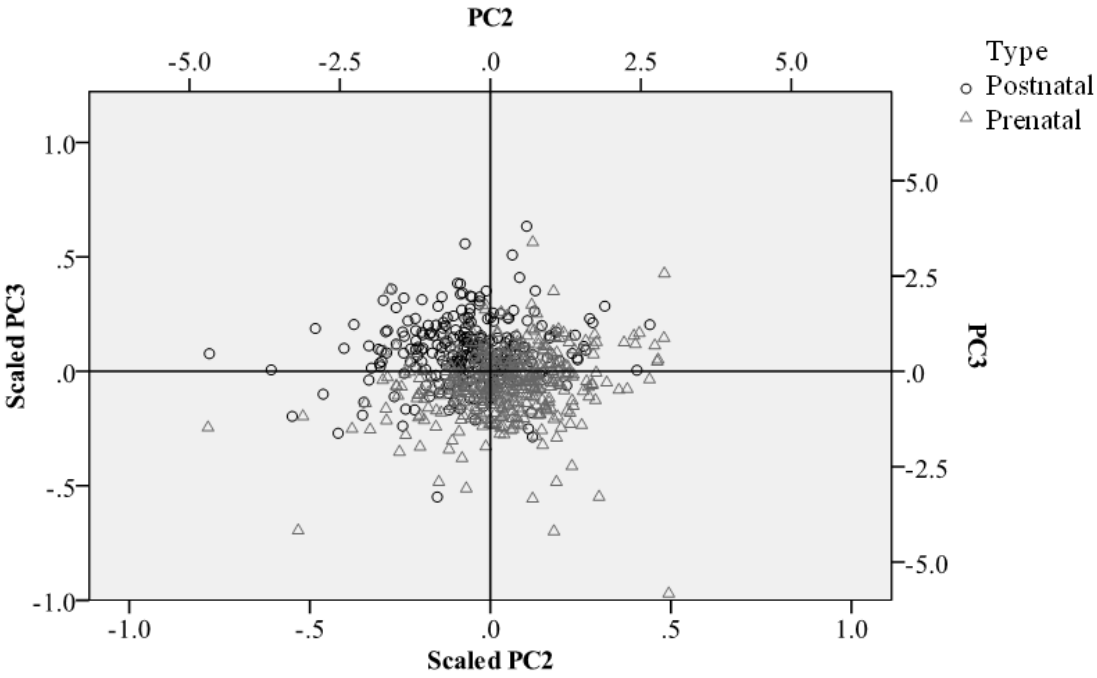


Figure 2.10. Loadings plot (top) and scores plot (bottom) of PC3 versus PC2.





The loadings plots for PC1 are shown in the plots in Figure 2.8. There was a trend that shorter chain-length PFCs loaded lower with the exception of PFPA. The six-carbon chain-length PFHxS loaded low, the eight-carbon chain-length PFOS and PFOA loaded around zero, and the nine to eleven-carbon chain-length PFNA, PFDA, and PFUA loaded high on PC1. PC1 also contained a trend that PFCs with shorter half-lives loaded lower than PFCs with longer half-lives, although this trend is somewhat unclear as discussed in the following two paragraphs. Because a trend for PC1 is not clear, PC1 may represent exposure to all PFCs from many consumer products.

The five-carbon chain-length PFPA did not follow the same trend on PC1 as other PFCs. As noted previously in section 2.3.2, the half-life of PFPA in humans, while unknown, is likely on the order of weeks based on estimates of PFBA and PFHxA (Chang et al., 2008; Nilsson et al., 2010). This is significantly shorter than the longer chain-length PFOA, which has an estimated half-life in humans on the order of years (Burris, 2002; Glynn et al., 2012; Olsen et al., 2007; Spliethoff et al., 2008). In humans, the half-lives of the longer chain-length PFCAs are expected to be longer than that of PFOA, as half-lives of PFNA and PFDA in rats are longer than the half-life of PFOA (Ohmori et al., 2003). The trend for PFCAs follows that lower loadings on PC1 were suggestive of shorter half-life, and higher loadings on PC1 were suggestive of longer half-life.

The short chain-length PFBS has a shorter half-life than PFHxS or PFOS in humans (Olsen et al., 2009). However, it is unclear whether PFHxS or PFOS has a longer half-life. In studies which have estimated the half-life of both PFHxS and PFOS in humans, it was determined that PFHxS had a longer half-life at 8.5 years and 8.2 years,

respectively, than PFOS at 5.4 years and 4.4 years, respectively (Olsen et al., 2007; Spliethoff et al., 2008). However, studies which have only estimated the half-life of PFOS have determined half-lives of 8.7 years (Burris, 2002) and 8.2 years (Glynn et al., 2012). Studies using cynomolgus monkeys (*Macaca fascicularis*) have found that the half-lives of PFHxS and PFOS were approximately the same (Chang et al., 2012; Sundstrom et al., 2012; Wilhelm et al., 2010). It is unclear whether shorter chain-length PFSAs loaded lower on PC1 because they have shorter half-lives.

The scores plots for PC1 shown in Figure 2.8 show that the majority of participants were influenced similarly by PC1 as most data points were grouped together. The participants one year after delivery had a significantly lower loading on PC1 than the participants during pregnancy (unpaired *t*-test), indicating that there were more short-chained PFCs in participants' plasma one year after delivery.

The loadings plots in Figure 2.8 show that for PC2, the order of increasing loadings is PFOS << PFPA ~ PFUA < PFDA < PFHxS < PFNA << PFOA. With the exception of PFPA, there was a trend of longer chain-length PFSAs and PFCAs loading lower on PC2 and shorter chain-length PFCAs and PFSAs loading higher on PC2. The trend on PC2 follows the same pattern as TEs of PFCs from the mother to the newborn (Table 2.11). For the PFSAs, PFOS loaded lower on PC2 and had a TE of 0.39, whereas PFHxS loaded higher on PC2 and had a TE of 0.55. For the PFCAs, PFDA loaded lower on PC2 and had a TE of 0.39 where PFOA loaded higher on PC2 and had a TE of 0.80. The TEs of PFUA and PFNA were not calculated because the majority of cord blood plasma concentrations were not above the LOQ for these two PFCs. However, a Korean study found that for PFCAs the TE decreased with every carbon chain increase (S. K.

Kim et al., 2011). A Norwegian study also found that shorter PFCs had higher TEs, and the PFCAs transferred more efficiently than the PFSAs (Gutzkow et al., 2012). If the TEs from participants in this study followed the same pattern as these other studies then the pattern for PC2 would follow that PFCs with low TEs loaded lower on PC2 and PFCs with high TEs loaded higher.

The median TE for PFPA was 1.0, and therefore PFPA did not follow the pattern of the rest of the PFCAs. Because PFPA is most likely eliminated from the body very quickly as previously discussed, it did not contribute to PC2 because the contribution of maternal transfer occurred over a longer period of time.

Breast milk was not analyzed in this study. Therefore, no measurement of maternal transfer through breast milk can be concluded from this study. However, the TEs from maternal serum to breast milk in China have been estimated in the order of PFOS < PFUA < PFDA ~ PFNA < PFHxS < PFOA (S. K. Kim et al., 2011). This order is similar to the order of PFCs for PC2, indicating that PC2 likely represents both prenatal and postnatal maternal transfer. Therefore, lower loading on PC2 indicates more maternal transfer and high loading on PC2 indicates less maternal transfer.

Prenatal samples loaded significantly higher than postnatal samples on PC2 (unpaired *t*-test). Therefore, prenatal samples showed less maternal transfer and postnatal samples showed more maternal transfer. The postnatal samples contained lower proportions of more easily transferred PFCs such as PFOA, because these PFCs had already been transferred prenatally and if the participant breastfed, postnatally as well. Prenatal samples contained higher proportions of more easily transferred PFCs such as PFOA because the samples were taken during pregnancy and therefore, less transfer had

occurred at that time point. The grouping of both the prenatal and postnatal samples around the center of the scores plot (Figure 2.8) indicates that for the majority of the samples, the maternal transfer had a similar contribution to the proportion of each PFC in plasma.

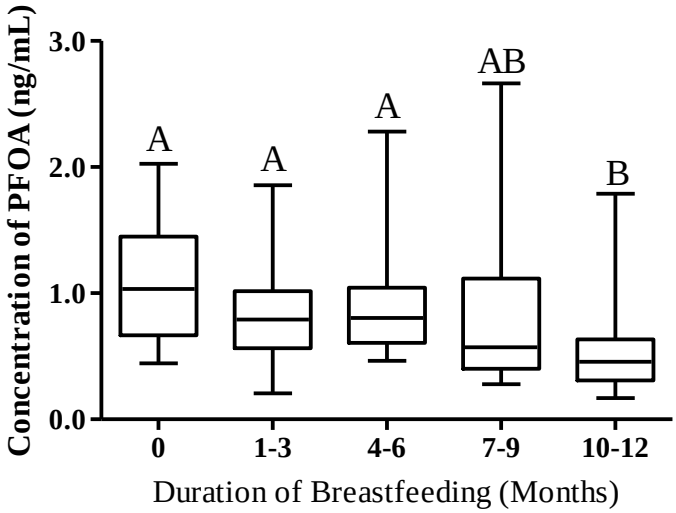
The loadings plot for PC3 in Figure 2.10 shows a low loading for PFOS and a high loading for PFPA. All other PFCs loaded close to zero on PC3. This suggests that PC3 represents more past-use PFC sources (PFOS) and more recent-use PFC sources (PFPA). PFOS stands out on its own as low on PC3, because it used to be the most commonly used PFC until it was phased out around year 2000. PFPA stands alone because shorter chain-length PFCs are being used as replacements for longer chain-length PFCs in recently manufactured products. The remaining PFCs have similar loadings on PC3 because they are used in many different products and often in mixtures so there would be exposure to all of these PFCs combined.

The scores plot (Figure 2.10) shows that the majority of participants had a mixture of more past-use and more recent-use sources in their plasma. The postnatal samples loaded significantly higher on PC3 than the prenatal samples (unpaired *t*-test), suggesting that participants had been exposed to more recent-use sources of PFCs postnatally than during pregnancy. The postnatal samples may have contained more recent-use PFCs because the sampling dates for postnatal were more recent than the prenatal samples (January 2010 to November 2011 for prenatal and June 2010 to May 2012 for postnatal samples). Additionally, the postnatal participants may have been exposed to more new consumer items at that time point. It is common that new consumer items are purchased or given as gifts when a baby is born and during their quick growth within the first year,

so exposure to these new items may have resulted in higher proportions of more recent-use PFCs in the postnatal participants.

In this work, it was found that those mothers who had breastfed for longer periods of time had lower PFOA plasma concentrations at one year after delivery (Figure 2.11). The concentrations in plasma for mothers who had never breastfed, breastfed for 1-3 months, breastfed for 4-6 months, breastfed for 7-9 months, and breastfed for 10-12 months were compared (Kruskal-Wallis test). Mothers who were still breastfeeding at the postnatal time point were included in the 10-12 month group. For all PFCs besides PFOA, there was no significant difference between the concentrations of the PFC in mothers' plasma between the different groups regarding duration of breastfeeding. Decreasing levels of PFOA with duration of breastfeeding suggests that PFOA was lost through the breast milk. PFOA has been measured in breast milk of mothers in various countries (Table 1.4). This compliments the finding that PFOA levels were significantly lower in mothers one year after delivery than during pregnancy in this study, as some PFOA would be lost through the breast milk. To further this, a Norwegian study of women where the majority had stopped breastfeeding several years before still had significantly lower levels of many PFCs if they had breastfed for four months or longer (Haug et al., 2010).

Figure 2.11. Box and whisker plot of concentration of PFOA versus duration of breastfeeding (n = 168).



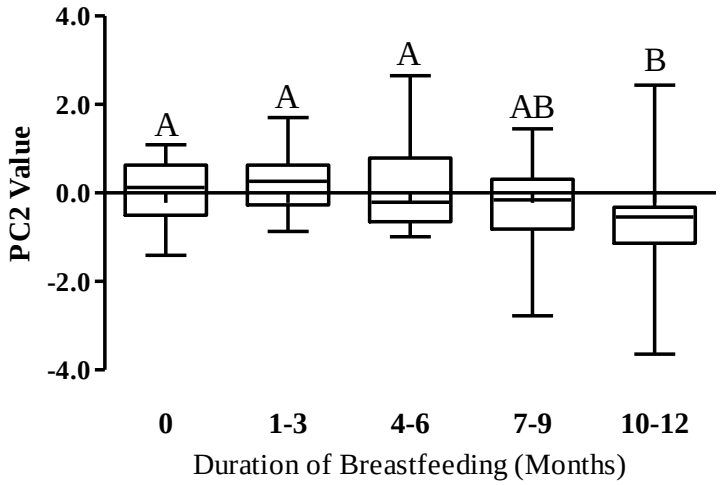
The whiskers show minimum to maximum values. Letters "A" and "B" denote statistically different values between groups and groups with the same letters were not significantly different (Dunn's multiple comparison test).

The values for PC1, PC2, and PC3 were compared to the number of months the mother breastfed for each postnatal participant to investigate whether the PCs were influenced by the duration of breastfeeding (one-way ANOVA). A significant difference between the values of PC2 and the duration of breastfeeding was found, but no significant difference with PC1 or PC3. The lack of association between PC1 and PC3 with the duration of breastfeeding indicates that PFC half-lives and more past-use versus more recent-use PFC sources are not significantly affected by breastfeeding.

There was an overall decreasing trend for PC2 with increasing duration of breastfeeding (Figure 2.12). The value of PC2 was significantly lower at 10-12 months of

breastfeeding than at 0, 1-3, and 4-6 months. These results indicate that participants who breastfed for a longer duration (10-12 months) had significantly more maternal transfer of PFCs then participants who did not breastfeed or breastfed for a shorter duration (1-6 months).

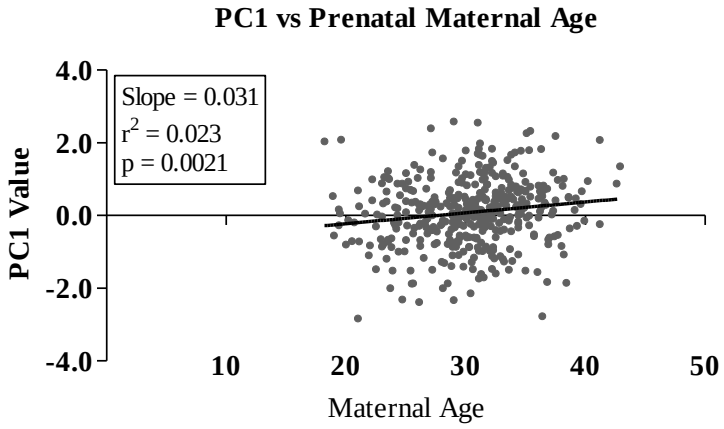
Figure 2.12. Values of PC2 compared to the number of months breastfed for postnatal participants (n = 168).

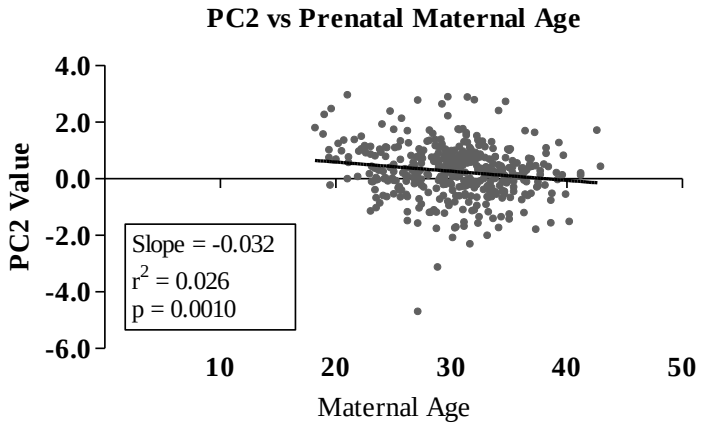


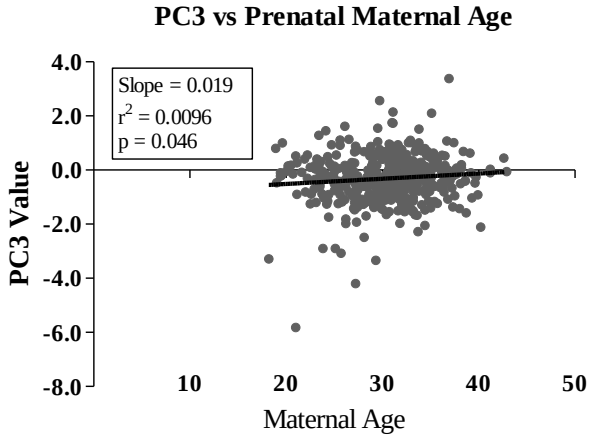
Letters "A" and "B" designate significantly different groups and groups with the same letters were not significantly different (Tukey's test).

The values for PC1, PC2, and PC3 were plotted against the maternal age of the participants at the time of sampling to investigate whether the PCs were influenced by maternal age (Figure 2.13). The slopes for all PCs were not significantly different from zero for the postnatal samples. Prenatal samples for all PCs had slopes significantly different than zero, although the r^2 values were low.

Figure 2.13. Values of PCs versus the maternal age at time of sampling (n = 413). The p-value indicates the slopes were significantly different than zero.



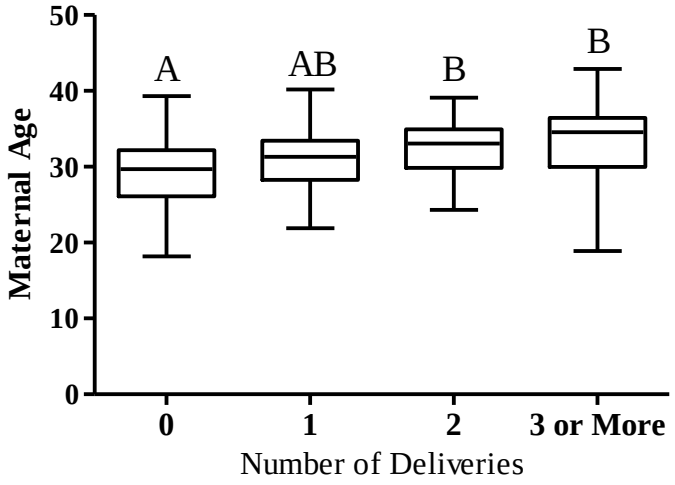




The positive association between maternal age and PC1 may suggest that older prenatal participants had higher proportions of longer chain-length PFCs in their plasma. Linear regression of prenatal PFC concentration and maternal age from this study showed that there was a significantly negative association between PFOA and PFHxS concentration and maternal age, but a significantly positive association between PFUA concentration and maternal age. Similarly, a Japanese study found that PFOS and PFOA levels had a significantly negative association with prenatal maternal age (Okada et al., 2012). Conversely, NHANES data from the U.S. showed that females had increased levels of PFOS, PFOA, PFHxS, and PFNA with increased age (Kato et al., 2011). The difference between the results of these studies may be because this study and the Japanese study only investigated the PFC concentration versus maternal age for pregnant women, where the U.S. study was for females regardless of parity.

For this study, the results of the association between maternal age and PC1 and the linear regression associations between PFOA, PFHxS, and PFUA suggested that there were higher proportions of longer half-life PFCs (PFUA) and lower proportions of shorter half-life PFCs (PFOA and PFHxS) with increased maternal age. This result seems reasonable as PFCs with longer half-lives would have more bioaccumulation and therefore be found in higher proportions. The negative association between maternal age and PC2 suggests that prenatal participants who were older had more maternal transfer than those who were younger. This may be because there is a positive trend of maternal age and number of babies delivered by the participant (Kruskal-Wallis test, Figure 2.14). Older age is associated with more deliveries, which may explain why maternal transfer would be greater in those samples.

Figure 2.14. Box and whisker plots of maternal age versus number of deliveries for prenatal samples (n = 219).



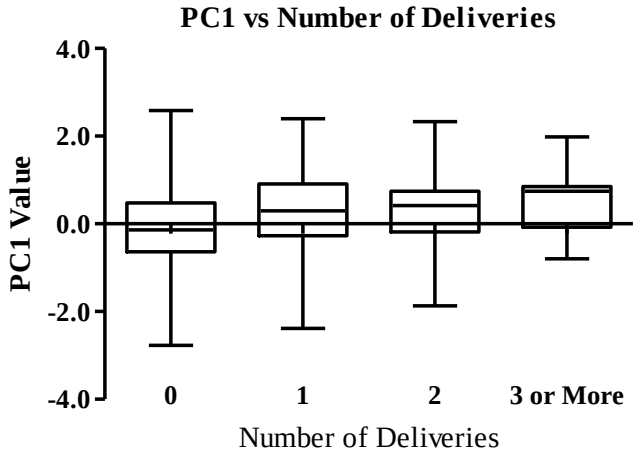
The whiskers show the minimum to maximum values. Letters "A" and "B" denote statistically different values between groups and groups with the same letters were not significantly different (Dunn's multiple comparison test).

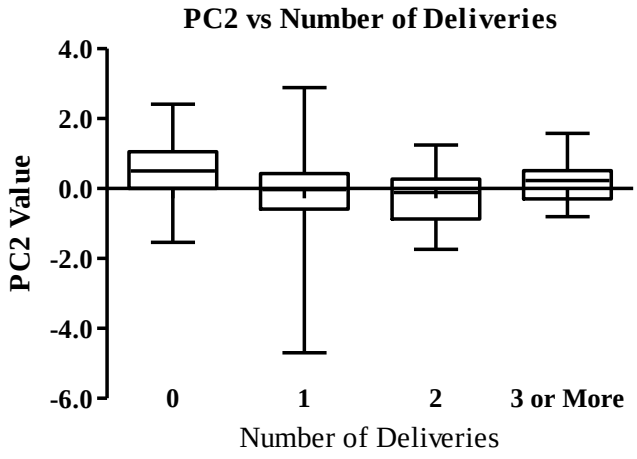
The positive association between maternal age and PC3 indicates that older participants were either exposed to more recent-use PFC sources, eliminated more past-use PFCs such as PFOS more quickly, or do not eliminate more recent-use PFCs such as PFPA as quickly. A study on 48 adults in Japan found there was no significant difference in renal clearances of PFOS and PFOA among different age groups (Harada et al., 2005). As previously discussed, the participants from this study showed significant associations between ubiquitous PFC concentrations (PFOA, PFHxS, and PFUA) and maternal age. However, no significant associations were found between more past-use and recent-use PFC concentrations (PFOS and PFPA) and maternal age. The results from a Japanese

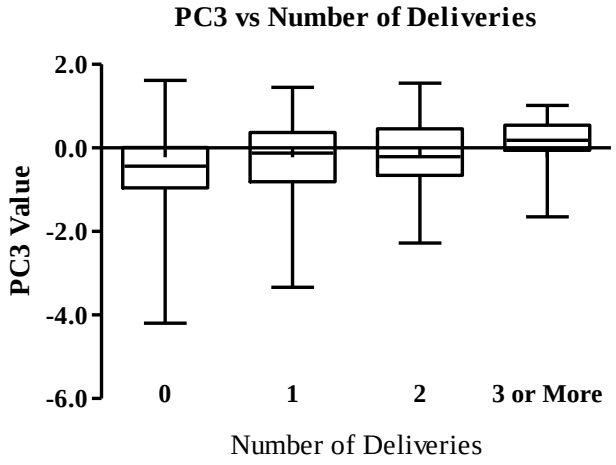
study found that PFOS concentrations were negatively associated with maternal age (Okada et al., 2012), but a study from the U.S. found that PFOS concentrations were positively associated with female age (Kato et al., 2011). Therefore, it is unclear why PC3 would increase with increasing age, but the r^2 value was small indicating a weak association. This weak association suggests that there are other factors accounting for the variability in PC3, and that age and bioaccumulation are not necessarily the most important contributing factors.

The values for PC1, PC2, and PC3 were compared to the number of babies delivered for each participant to investigate whether the number of deliveries influenced the PCs (one-way ANOVA). The values of the PCs were not significantly different for the postnatal samples, but were significantly different for the prenatal samples (Figure 2.15).

Figure 2.15. Box and whisker plots of PC values versus number of deliveries for prenatal samples (n = 219). Whiskers show the minimum to maximum values.







There was an increasing trend for PC1 and the number of deliveries. This suggests that participants who have delivered more babies had higher proportions of longer chain-length PFCs with longer half-lives. This result may be because of the positive association between maternal age and the number of deliveries, and therefore, the higher proportion of longer chain-length PFCs in participants who had delivered more babies may be related to their increased age compared to those who had fewer children to date.

The decreasing trend for PC2 and the number of deliveries suggests that participants who had delivered more babies had more maternal transfer. The mean value of PC2 increased with three or more deliveries, but not significantly (Tukey's test). Perhaps after three or more deliveries, the overall levels of PFCs were more dilute and therefore the proportions become more skewed with constant exposure to various PFCs.

The increasing trend for PC3 and the number of deliveries suggests that participants who had delivered more babies had higher proportions of PFCs found in newer products such as PFPA. This result agrees with the conclusion that participants who had a higher number of deliveries have had more maternal transfer. Therefore, when these participants are exposed to PFCs such as PFPA, there will be a higher proportion of PFPA because the proportion of other PFCs like PFOS in their plasma would be lower.

Various environmental factors regarding participants' homes were investigated to determine whether these factors influenced the concentrations of PFCs in plasma. PFCs are present in consumer products such as stain repellents for carpets, upholstery, and paints. The ratio of PFCs used in consumer products is thought to have changed throughout time because of the phase-out of different PFCs. Therefore, exposure to PFCs may be related to exposure to these items in the home, and the age of these items.

No significant differences were seen between the decade when homes were built or what percentage of carpet was present in the most used room in relation to the three PCs (one-way ANOVA) or concentrations of individual PFCs (Kruskal-Wallis test). No significant differences were seen between whether or not new furniture had recently been brought into the home or whether home renovations had been recently done in relation of the three PCs (unpaired *t*-test) or concentrations of individual PFCs (Mann-Whitney test). These results suggest that either too small an amount of PFCs was released from items in the homes, or that the contribution of the released PFCs in comparison to other PFC sources was not large enough to influence the distributions of PFCs in plasma.

The limitation of this study, when comparing home characteristics to PFCs in plasma, is that it is unknown how these characteristics influence PFC concentrations and distributions in participants' homes. Therefore, it is unknown how the home characteristics affect exposure routes, such as indoor air and dust, to participants. Previous studies have shown that home characteristics, such as age of home and carpeting, were associated with PFC levels in indoor air and/or dust (Gewurtz et al., 2009; Haug et al., 2011; Kubwabo et al., 2005). Although indoor air and dust is thought to be a less important exposure route of PFCs compared to diet (Egeghy & Lorber, 2011; Fromme et al., 2009; Tittlemier et al., 2007), one study found that FTOHs in indoor office air were associated with PFOA concentrations in serum from people who worked in the office (Fraser et al., 2012), indicating that PFCs in the indoor air can influence blood PFC levels.

2.3.5. PFC Concentrations in Plasma and Incidence of Wheezing in Infants

The incidence of wheezing in infants of this study was compared to PFC concentrations in maternal plasma in order to determine whether or not relationships existed. No significant differences were found between infants with recurrent wheezing and control group infants for individual concentrations of PFCs (Mann-Whitney test). Additionally, no significant differences were found between wheeze group and control group infants for the three PCs (unpaired *t*-test). These observations indicate that the proportions and concentrations of PFCs measured in this set of plasma did not affect the occurrence of wheezing. However, the sample numbers for these comparisons were low (wheezing group n = 51, control group n = 34) and therefore further investigation with a larger sample size may yield different results. The results of this study agree with the one other study that compared PFC levels and wheezing in Japan (Okada et al., 2012) where no correlations were found. This study compared the concentrations of seven PFCs, including PFOS and PFOA, to the incidence of wheezing, where the other existing study compared only PFOS and PFOA.

The likelihood of a child developing asthma later in life can be assessed using an asthma predictive index (Castro-Rodriguez et al., 2000), which uses clinical parameters assessed in the child early in life. Children who rank positively on the asthma predictive index are likely to have asthma later in life. For example, children who rank positively on the asthma predictive index have been found to be 4.3 to 9.8 more times likely to develop asthma later in childhood when stringent criteria were used (Castro-Rodriguez et al., 2000). Another study has changed some of the criteria of the asthma predictive index and included additional criteria that have associations with asthma (Guilbert et al., 2004) and

renamed it the ‘modified asthma predictive index’. The criteria for the modified asthma predictive index is as follows: the child has four or more wheezing episodes with at least one diagnosed by a physician plus one of: parental history of asthma, atopic dermatitis diagnosed by a physician, allergic sensitization to at least one aeroallergen, or two of: an allergic sensitization to milk, egg, or peanuts, wheezing episodes without presence of a cold, or blood eosinophil levels of at least four percent (Guilbert et al., 2004).

The group of infants with recurrent wheezing (n = 51) and the control group (n =34) were further evaluated for their scores on the modified asthma predictive index. The criterion for the index was changed slightly due to availability of the survey data. A positive ranking on the index was determined by two or more wheezing episodes without wheezing diagnosed by a physician (opposed to four episodes with physician diagnosis (Guilbert et al., 2004)). Relative blood eosinophil levels were only available for seven infants, which lowered the n value.

No significant differences were found between infants who ranked positively on the modified asthma predictive index (n = 22) and those who ranked negatively (n = 7) for individual concentrations of PFCs (Mann-Whitney test) with the exception of PFOA. The concentration of PFOA was significantly lower for participants who ranked positively on the index than those who ranked negatively. This result does not agree with laboratory studies that have found PFOA exposure to cause changes in the lungs such as increased levels of PPARα (Abbott et al., 2012; Rosen et al., 2007), which may cause developmental toxicity (Abbott et al., 2009). It should be noted that the sample numbers were small, and therefore, larger sample numbers may produce different results. Additionally, no significant differences were found between prenatal maternal PFC

concentrations for positive rank and negative rank infants for the three PCs (unpaired *t*-test). In general, PFC concentrations and distributions were not found to be significant in predicting the occurrence of asthma using the modified asthma predictive index.

2.3.6. Aspects of Fetal Growth

Studies have investigated whether concentrations of PFCs in blood are related to aspects of fetal growth such as weight and length of infant at birth, head circumference, and gestational age (as discussed in section 1.8). It is unclear whether PFCs affect fetal growth in humans, as contradicting results have been found as to whether there are correlations with PFCs and aspects of fetal growth. These aspects could be indicative of developmental effects. Low birth weight, birth length, and ponderal index could be the result of insufficient growth during gestation. Unusually small or large head circumference could be the result of abnormal brain development. Low birth weight, altered brain development, and gestational effects have all been observed in animal studies when mice were dosed with high levels of PFCs (Hines et al., 2009; Johansson et al., 2009; Lau et al., 2006). Therefore, these possible outcomes of developmental effects were assessed in this study population.

Prenatal plasma was used to evaluate aspects of birth in place of cord blood plasma in this study. Many previous studies have used prenatal maternal samples to investigate aspects at the time of birth, such as birth weight (Stein et al., 2009; Whitworth et al., 2012; Hamm et al., 2010; Fei et al., 2008).

Multiple linear regression was preformed to investigate whether there were correlations between infant birth weight, birth length, ponderal index, head

circumference, or gestational age and the concentration of PFCs in maternal plasma during pregnancy. The variables used to determine these outcomes were the natural log of the concentration of each PFC, the maternal age, whether or not the mother smoked during pregnancy, whether or not the mother had high blood pressure during pregnancy, whether or not the mother had diabetes during pregnancy, parity, and infant sex. Additionally, gestational age was used as a variable for birth weight, birth length, and head circumference. Whether the delivery was vaginal or via caesarian section was also used as a variable for head circumference.

The correlations between all PFCs and birth length, ponderal index, head circumference, and gestational age were all non-significant. However, there was a significantly negative correlation between the concentration of PFUA and birth weight (slope b = -76 with 95% confidence intervals of -140 to -6.3, standardized slope β = -0.16). Therefore, for every unit increase in natural log concentration of PFUA the birth weight decreased by 76 g. The correlations between birth weight and concentration for all other PFCs were negative but not significant. Other studies investigating relationships between PFC concentrations and birth weight have focused on PFOS and PFOA (Apelberg et al., 2007; Fei et al., 2007; Savitz et al., 2012; Whitworth et al., 2012). However, one other study did investigate PFUA and found that there was a negative association between natural log concentration of PFUA and birth weight, but it was not significant (Chen et al., 2012).

The numbers of developmental toxicity studies that have been done on PFUA are limited. In chickens, the time to the first stage of hatching was not affected by dosing with PFUA (O'Brien et al., 2009). An *in vitro* study on mice and human cells including

PFUA found that the PPARα pathway had increased activity with increasing chain-length of PFCAs (Wolf et al., 2012), and alteration of the PPARα pathway may cause developmental toxicity (Abbott et al., 2007). It is possible that the presence of the long-chain PFUA is involved in causing developmental toxicity such as decreased birth weight in humans. However, this finding is contradictory to the other study, which found no significant correlation between PFUA and birth weight and therefore, further investigation is required to draw conclusions.

2.4. Summary of Chapter 2

Seventeen PFCs were measured in cord blood plasma and pre- and postnatal maternal plasma using a sample preparation method adapted from Mosch et al. (2010) and an LC-MS/MS method adapted from Gosetti et al. (2010) and Haug et al. (2009b). Strong correlations were found between PFCs in cord blood plasma and prenatal maternal plasma. Seven PFCs (including PFOS and PFOA) had median values over the LOQ in maternal plasma samples and were used for statistical analysis.

Many maternal characteristics (e.g. age, parity) were correlated to PFC concentrations and distributions in plasma. With a few exceptions, home characteristics (e.g. age of home, amount of carpeting), developmental effects (e.g. birth weight, gestational age), and occurrence of wheezing were not correlated to PFC concentrations or distributions in plasma.

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Chapter 3 Conclusions and Future Directions

The overall goal of this study was to measure the concentrations of 17 PFCs in blood plasma from participants from Winnipeg, Manitoba and compare these results with various aspects of the participants' lives to investigate possible correlations. This was achieved by adapting existing methods involving online SPE coupled with LC-MS/MS, and using survey results from participants and their physicians. The method used to measure PFCs had low detection limits, minimal sample preparation, and required a small amount of plasma. Therefore, the method was suitable for large-scale quantification of plasma. In total, plasma samples were tested from 414 women during their pregnancy, 247 women one year after they delivered their baby, and 50 infants at the time of birth. Numerous PFCs were present in all 711 samples tested, demonstrating there is exposure of PFCs to people in Winnipeg. PFC concentrations in blood were similar to what has been found from other recent studies for commonly detected PFCs (Gutzkow et al., 2012; Kim et al., 2011; Liu et al., 2011). The concentrations and distributions of PFCs in the participants' plasma were compared to many maternal, infant, and home characteristics. This allowed new insights regarding how these characteristics were related to PFC concentrations in plasma.

PFCs such as PFOS and PFOA had measured concentrations that were lower in these samples than what was measured in blood the early to mid-2000s when the phase-out of manufacturing of some of these chemicals had recently been executed (Midasch et al., 2007; Whitworth et al., 2012; Woodruff et al., 2011). The decreasing concentrations of PFOS and PFOA in blood are consistent with other studies (Glynn et al., 2012; Olsen et al., 2012). However, an increase in the short chain-length PFPA in these samples was

observed, which indicates the use of this PFC as a replacement for longer chain-length PFCs. It would be interesting for future studies to analyse blood samples for short chain-length PFCs, such as PFPA, as well as the four carbon chain-length PFBA to see how these levels in blood change in the future.

It was determined that there were no correlations between the concentrations or proportions of each PFC in maternal plasma and the incidence of wheezing in infants. The lack of correlation may be for one or more of the following reasons: because PFCs do not cause harmful effects on human lungs though they have in mouse lungs (Grasty et al., 2005), that the PFC concentrations were too low to elicit effects, or that the outcome of wheezing was not observed while other effects (not measured here) on the lungs may have occurred.

Principal component analysis showed that the proportions of PFCs in maternal plasma were influenced by PFC half-lives and chain lengths, maternal transfer, and older PFC sources or newer PFC sources. The proportions and concentrations of PFCs in plasma were affected by the sampling time point (pre- or postnatal), maternal age, number of babies delivered by the mother, and duration of breastfeeding. This showed that the distribution of PFCs in plasma is affected by many factors.

In general, no correlations were found between PFCs in plasma and home characteristics or aspects of fetal growth. However, a negative association was found between PFUA concentrations and birth weight. These results suggest for the most part that PFCs are not influenced by home characteristics and do not influence aspects of fetal growth. Interestingly, PFUA had the lowest median concentration but was the only PFC to have a significant association with birth weight. This suggests that the longer chain-

length PFCs could be more toxic to humans in terms of developmental effects. Future studies on the relationship between PFCs and birth defects should investigate longer chain-length PFCs such as the 12 to 14 carbon chained PFCAs.

In this work, plasma samples were analyzed from mothers at different time points. An interesting addition to this study would be the measurement of PFCs in breast milk from the participants whose blood has been analyzed for PFCs. Study participants donated breast milk samples, so samples are available. The transfer of PFCs from the mothers' breast milk to their infant could be evaluated from the PFC concentrations in the breast milk. Additionally, investigations could be made as to whether the concentrations of PFCs in breast milk change over time and if TEs between plasma and breast milk differ between different PFCs. This could relate to the findings of this study that women who breastfed for longer had more maternal transfer.

In this study, cord blood plasma was analyzed for PFCs from infants at the time of birth. Another interesting addition to this study would be to measure to concentrations of PFCs in the infants as they age. A subset of samples taken from infants at one-year increments until they are five years old could be analyzed as the CHILD study continued to take blood from the child participants at these time points. This would provide data as to whether breast milk is a significant source of PFCs and would provide a longitudinal study on how PFC levels change in young children from Winnipeg, Manitoba. Few longitudinal studies on PFC levels in infants and young children have been conducted (Fromme et al., 2010) and none in Winnipeg.

Further research on the exposure routes of PFCs to people in Winnipeg could be investigated. The levels of PFCs in air and dust samples from CHILD participants are

currently being evaluated by another graduate student in our research group. The results of air and dust samples could be compared to the results from plasma to investigate how this route of exposure influences PFC levels in blood. Additionally, the exposure of PFCs through the diet of participants would give insight on how this exposure route influences PFCs in plasma. Participants' filled out surveys regarding their diet, and information regarding PFC levels in food from Canada is available (Tittlemier et al., 2006; Tittlemier et al., 2007).

Home characteristics did not appear to affect the PFC distribution in plasma. These results suggest that either there are too many sources of PFCs to humans for the home characteristics to make a difference in plasma distribution, that the concentrations of PFCs being emitted from different sources in the home are not at high enough concentrations to affect PFC plasma distribution, or a combination of both. Data regarding indoor home air and dust could be compared to these home characteristics to investigate associations, and could therefore be evaluated for exposure to humans.

3.1. References

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Appendices

For all appendix tables, prenatal maternal plasma is abbreviated as “PNM”, postnatal maternal plasma one year after delivery is abbreviated as “1YRM”, and cord blood plasma is abbreviated as “CD”. For plasma concentrations, “N.D.” means the analyte was not detected. Sample IDs with the same number indicate matched samples (e.g. 40110 PNM was from the same participant as 40110 1YRM and was also the mother of the infant 40110 CD). For categories where matched samples were analyzed, sample IDs that have matched prenatal and postnatal maternal samples are marked with “*”. Sample IDs that have matched prenatal maternal and cord blood samples are marked with “•”.

Appendix A: Concentrations of PFCAs and PFSAs in maternal plasma during pregnancy (ng/mL).

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40074 PNM*	0.41	N.D.	N.D.	0.34	0.35	0.19	0.16	N.D.	0.11	2.5	0.069
40091 PNM	0.76	N.D.	0.21	1.2	0.38	0.20	0.075	N.D.	0.30	1.2	N.D.
40110 PNM*•	0.56	0.059	N.D.	0.45	0.33	0.13	0.17	N.D.	0.37	3.3	N.D.
40124 PNM*	0.34	N.D.	0.062	0.58	0.39	0.18	0.20	N.D.	0.14	1.8	N.D.
40134 PNM*	0.41	N.D.	0.059	0.74	1.2	0.60	0.48	N.D.	0.41	11	0.14
40138 PNM*•	0.71	0.25	0.072	1.0	0.25	0.10	0.055	N.D.	0.30	2.5	0.070
40139 PNM*	0.44	N.D.	N.D.	0.31	0.22	0.11	0.067	N.D.	0.35	1.9	N.D.
40140 PNM*	0.71	N.D.	0.042	0.64	0.45	0.19	0.19	N.D.	0.23	2.5	0.076
40142 PNM*	0.54	N.D.	0.046	0.49	0.32	0.14	0.12	N.D.	0.90	2.0	0.047
40143 PNM*	0.48	N.D.	0.056	0.96	0.46	0.20	0.13	N.D.	0.27	3.0	N.D.
40144 PNM*•	0.44	N.D.	N.D.	0.52	0.30	0.058	0.023	N.D.	0.067	0.18	0.042
40145 PNM	0.52	N.D.	N.D.	1.1	0.56	0.22	0.15	N.D.	0.45	3.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40146 PNM*	0.36	N.D.	0.039	3.8	0.88	0.37	0.18	N.D.	2.3	5.3	N.D.
40147 PNM*	0.68	0.056	0.030	0.74	0.53	0.13	0.083	N.D.	0.43	2.5	0.12
40148 PNM*	0.59	N.D.	0.039	0.97	0.52	0.18	0.17	N.D.	0.35	2.1	0.058
40149 PNM	0.38	N.D.	0.024	1.0	0.38	0.13	0.064	N.D.	0.95	1.4	N.D.
40150 PNM*	0.38	N.D.	0.033	0.83	0.49	0.14	0.10	N.D.	0.42	2.7	N.D.
40151 PNM	0.37	N.D.	N.D.	0.70	0.38	0.11	0.054	N.D.	0.29	1.3	0.033
40156 PNM*	0.50	N.D.	0.051	0.89	0.46	0.14	0.066	N.D.	0.17	1.1	N.D.
40157 PNM*	0.98	N.D.	0.062	0.81	0.73	0.13	0.12	N.D.	0.21	2.3	N.D.
40158 PNM*	1.1	N.D.	0.027	1.5	0.36	0.13	0.040	N.D.	2.8	2.0	N.D.
40159 PNM*	0.51	0.034	0.040	1.2	0.46	0.18	0.19	0.001	0.49	3.2	N.D.
40160 PNM	0.20	N.D.	N.D.	1.2	0.21	0.077	0.073	N.D.	0.77	0.88	0.044
40161 PNM*•	0.55	N.D.	0.087	1.4	0.40	0.14	0.060	N.D.	0.54	2.6	0.083
40162 PNM*	0.70	N.D.	0.044	1.3	0.40	0.14	0.047	N.D.	0.44	3.9	0.047

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40163 PNM	0.09	N.D.	0.046	1.2	0.44	0.14	0.089	N.D.	0.52	2.4	0.053
40164 PNM*	0.43	N.D.	0.057	1.3	0.36	0.14	0.053	N.D.	0.36	2.3	N.D.
40165 PNM	0.68	N.D.	N.D.	1.3	0.37	0.096	0.078	N.D.	4.9	5.4	N.D.
40166 PNM*	0.34	N.D.	0.041	1.6	0.34	0.11	0.073	N.D.	3.4	3.1	0.047
40167 PNM	0.81	N.D.	0.014	1.5	0.36	0.099	0.094	N.D.	1.8	2.9	0.059
40168 PNM	0.49	N.D.	0.068	1.2	0.37	0.10	0.070	N.D.	0.39	1.9	N.D.
40169 PNM*	0.60	0.015	0.023	0.37	0.28	0.12	0.14	N.D.	0.29	2.5	0.079
40170 PNM*	0.25	N.D.	N.D.	0.68	0.27	0.11	0.028	N.D.	0.64	2.1	N.D.
40171 PNM	0.44	N.D.	N.D.	1.1	0.33	0.12	0.070	N.D.	0.84	2.1	N.D.
40172 PNM*	0.19	N.D.	N.D.	0.89	0.24	0.11	0.074	N.D.	0.30	1.5	N.D.
40173 PNM	0.43	N.D.	0.006	0.72	0.51	0.24	0.24	N.D.	N.D.	3.5	0.058
40175 PNM*	0.87	N.D.	0.054	0.55	0.25	0.074	0.053	N.D.	0.19	0.73	0.048
40176 PNM*	0.47	N.D.	N.D.	0.28	0.20	0.082	0.076	N.D.	0.22	0.85	0.049

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40177 PNM*	0.22	N.D.	0.057	0.68	0.78	0.27	0.15	N.D.	0.20	6.5	0.076
40178 PNM*	0.47	N.D.	0.014	1.4	0.48	0.17	0.070	N.D.	3.7	2.9	N.D.
40179 PNM*	0.39	N.D.	N.D.	1.2	0.37	0.10	0.038	N.D.	0.36	4.1	0.067
40180 PNM*	0.67	0.027	0.055	1.6	0.43	0.16	0.077	N.D.	0.46	1.9	0.041
40181 PNM	0.27	N.D.	N.D.	1.1	0.39	0.16	0.12	N.D.	0.31	3.2	0.055
40185 PNM*•	0.54	N.D.	0.049	0.99	0.29	0.12	0.084	N.D.	2.7	2.4	0.068
40186 PNM*	0.38	N.D.	0.044	0.48	0.39	0.13	0.11	N.D.	0.54	1.6	0.041
40187 PNM*	0.45	N.D.	N.D.	0.74	0.33	0.13	0.064	N.D.	1.4	2.2	0.061
40188 PNM*	0.38	N.D.	N.D.	0.90	0.33	0.11	0.033	N.D.	2.0	1.5	N.D.
40190 PNM*	0.84	0.015	N.D.	0.70	0.33	0.13	0.12	N.D.	0.68	1.8	0.053
40192 PNM*	0.56	N.D.	0.057	1.3	0.62	0.17	0.059	N.D.	0.32	4.0	N.D.
40193 PNM*	0.56	N.D.	0.056	0.69	0.30	0.099	0.026	N.D.	0.18	1.3	N.D.
40194 PNM*	0.36	N.D.	0.066	1.7	0.56	0.22	0.26	N.D.	0.55	3.9	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40195 PNM*•	0.52	N.D.	N.D.	0.23	0.20	0.078	0.019	N.D.	0.080	0.73	N.D.
40196 PNM*•	0.34	N.D.	0.007	0.53	0.29	0.12	0.085	N.D.	0.24	0.82	N.D.
40197 PNM*	0.26	N.D.	N.D.	1.4	0.93	0.16	0.20	N.D.	1.3	4.2	N.D.
40198 PNM*	0.66	N.D.	N.D.	1.5	0.90	0.19	0.12	N.D.	0.77	3.2	N.D.
40203 PNM*	0.50	N.D.	N.D.	1.4	0.41	0.16	0.14	N.D.	0.50	4.7	N.D.
40204 PNM	0.61	N.D.	N.D.	0.73	0.72	0.39	0.54	N.D.	0.23	3.5	0.063
40205 PNM*	0.31	N.D.	N.D.	1.0	0.43	0.15	0.070	N.D.	0.45	1.8	N.D.
40206 PNM*	0.36	N.D.	0.052	2.2	0.59	0.21	0.26	N.D.	2.3	4.5	N.D.
40209 PNM*	0.51	N.D.	0.015	1.0	0.44	0.16	0.095	N.D.	0.78	2.8	0.070
40210 PNM	0.85	N.D.	N.D.	0.55	0.17	0.068	0.021	N.D.	0.28	1.4	N.D.
40211 PNM*•	0.56	N.D.	N.D.	0.65	0.36	0.17	0.15	N.D.	0.18	1.1	N.D.
40212 PNM	0.30	N.D.	N.D.	1.1	0.40	0.16	N.D.	N.D.	3.0	1.8	N.D.
40213 PNM	0.45	N.D.	N.D.	1.3	0.35	0.11	0.089	N.D.	0.49	2.2	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40215 PNM	0.43	N.D.	0.033	1.8	1.0	0.36	0.15	N.D.	2.0	9.6	N.D.
40218 PNM*	0.56	N.D.	N.D.	1.4	0.49	0.15	0.073	N.D.	0.44	2.6	N.D.
40224 PNM	0.62	N.D.	0.11	0.58	0.28	0.094	N.D.	N.D.	0.31	1.3	N.D.
40225 PNM*	0.65	N.D.	N.D.	1.4	0.43	0.098	0.066	N.D.	0.36	1.4	N.D.
40226 PNM	N.D.	N.D.	0.050	1.4	0.46	0.18	0.12	N.D.	4.4	4.9	N.D.
40227 PNM	0.64	N.D.	0.060	0.99	0.25	0.092	0.067	N.D.	0.25	2.5	N.D.
40228 PNM	0.41	N.D.	N.D.	1.8	0.68	0.21	0.14	N.D.	0.35	2.3	N.D.
40232 PNM*	0.45	N.D.	0.069	0.70	0.28	0.11	0.049	N.D.	0.39	1.4	0.049
40235 PNM*	0.85	N.D.	0.039	2.0	0.41	0.17	0.075	N.D.	2.8	5.2	N.D.
40241 PNM	0.45	N.D.	0.045	0.88	0.34	0.12	0.051	N.D.	0.44	2.4	0.024
40243 PNM*	0.39	N.D.	N.D.	0.62	0.30	0.12	0.062	N.D.	0.21	2.3	N.D.
40244 PNM*•	0.73	N.D.	N.D.	2.9	0.54	0.20	0.080	N.D.	1.7	4.2	0.061
40245 PNM*	0.41	N.D.	N.D.	0.73	0.46	0.18	0.20	N.D.	0.53	2.9	0.056

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40246 PNM*	0.38	N.D.	N.D.	0.49	0.54	0.24	0.27	N.D.	N.D.	3.4	0.065
40247 PNM*	0.66	N.D.	0.046	0.78	0.32	0.15	0.037	N.D.	0.28	3.2	0.046
40248 PNM	0.35	N.D.	0.034	0.68	1.1	0.32	0.20	N.D.	0.22	8.4	0.076
40249 PNM	0.23	N.D.	0.036	0.87	0.36	0.13	0.13	N.D.	3.2	4.0	N.D.
40250 PNM*	0.49	N.D.	0.046	0.73	0.19	0.088	N.D.	N.D.	0.28	2.1	N.D.
40252 PNM*•	0.15	N.D.	0.055	0.56	0.32	0.11	0.056	N.D.	0.21	1.0	N.D.
40254 PNM*•	0.99	N.D.	N.D.	0.52	0.36	0.13	0.077	N.D.	0.30	3.3	0.080
40255 PNM*	0.40	N.D.	N.D.	0.77	0.51	0.18	0.092	N.D.	0.35	3.4	N.D.
40256 PNM*	0.53	N.D.	0.036	0.87	0.34	0.12	0.054	N.D.	0.67	2.1	0.056
40257 PNM*	0.68	N.D.	N.D.	0.99	0.34	0.28	0.038	N.D.	0.29	2.2	N.D.
40258 PNM*	N.D.	N.D.	0.056	0.56	0.29	0.15	0.14	N.D.	0.16	1.8	0.054
40259 PNM*	0.46	N.D.	N.D.	0.89	0.31	N.D.	0.032	N.D.	0.32	2.3	N.D.
40260 PNM	0.58	0.019	0.078	0.95	0.29	0.11	0.041	0.038	1.7	5.7	0.067

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40261 PNM*	0.79	N.D.	0.045	0.97	0.29	0.12	0.033	N.D.	0.15	0.97	0.042
40264 PNM*	0.23	N.D.	0.042	0.49	1.3	0.51	0.68	N.D.	0.45	5.9	0.074
40265 PNM*	0.49	N.D.	N.D.	1.3	0.51	0.21	0.12	N.D.	0.26	1.8	N.D.
40268 PNM*	0.66	N.D.	0.070	0.55	0.26	0.089	0.017	N.D.	0.77	1.8	N.D.
40269 PNM*	0.13	N.D.	0.069	0.48	0.26	0.095	0.048	N.D.	N.D.	0.81	N.D.
40271 PNM*	0.69	N.D.	0.073	0.25	0.13	N.D.	0.013	N.D.	0.14	0.52	N.D.
40272 PNM*	0.59	0.067	0.094	1.1	0.28	0.13	0.061	N.D.	0.59	1.4	N.D.
40273 PNM*	0.73	0.22	0.11	1.0	0.64	0.40	0.31	N.D.	0.21	1.9	0.064
40274 PNM*	0.67	N.D.	N.D.	0.96	0.81	0.15	0.14	N.D.	0.92	2.4	0.070
40275 PNM	0.71	N.D.	0.043	0.70	0.34	0.13	0.10	N.D.	1.7	2.4	N.D.
40276 PNM*	0.53	N.D.	N.D.	0.18	0.17	N.D.	0.056	N.D.	N.D.	1.1	N.D.
40279 PNM*	0.63	N.D.	0.042	0.61	0.27	0.099	0.055	N.D.	0.53	2.5	N.D.
40280 PNM*	0.52	0.037	0.061	0.36	0.24	0.12	0.057	N.D.	0.97	1.3	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40284 PNM*	0.48	N.D.	N.D.	0.38	0.32	0.14	0.084	N.D.	0.16	1.2	0.046
40287 PNM	0.41	N.D.	0.063	1.2	0.34	0.11	0.046	N.D.	0.72	2.1	0.026
40288 PNM	0.59	N.D.	N.D.	0.84	0.36	0.14	0.089	N.D.	0.33	2.2	N.D.
40289 PNM*•	0.66	N.D.	N.D.	1.3	0.44	0.17	0.035	N.D.	0.24	4.9	N.D.
40290 PNM*	1.5	N.D.	N.D.	0.32	0.28	0.085	0.017	N.D.	2.0	1.2	0.050
40291 PNM*	0.29	N.D.	N.D.	1.6	0.34	0.14	0.063	N.D.	0.45	4.2	N.D.
40295 PNM*	0.25	N.D.	0.053	0.71	0.35	0.15	0.067	N.D.	0.14	1.6	N.D.
40296 PNM	N.D.	N.D.	0.074	0.56	0.28	0.083	0.059	N.D.	0.25	2.0	0.038
40297 PNM*	0.33	N.D.	0.089	1.5	0.69	0.20	0.18	N.D.	0.56	3.9	N.D.
40300 PNM	0.54	N.D.	0.075	1.7	0.53	0.21	0.17	N.D.	1.6	3.6	N.D.
40301 PNM*	0.59	N.D.	0.058	1.1	0.36	0.096	0.031	N.D.	1.5	1.8	N.D.
40302 PNM*	0.63	N.D.	N.D.	0.56	0.41	0.21	0.19	N.D.	0.77	1.7	0.066
40303 PNM•	0.62	N.D.	0.10	1.5	0.38	0.13	0.041	N.D.	0.36	3.8	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40305 PNM•	0.69	N.D.	0.058	0.93	0.59	0.59	0.48	N.D.	0.88	4.2	0.039
40306 PNM*•	0.55	N.D.	0.042	0.43	0.29	0.17	0.064	N.D.	0.35	4.8	N.D.
40311 PNM	0.44	N.D.	0.085	4.8	1.9	0.64	0.28	N.D.	0.53	2.2	N.D.
40312 PNM*•	1.1	N.D.	0.047	0.97	0.32	0.12	0.094	N.D.	0.44	1.4	0.056
40313 PNM*	0.23	N.D.	0.058	0.47	0.36	0.10	0.027	N.D.	0.22	1.4	N.D.
40315 PNM	0.93	N.D.	0.075	0.26	0.17	0.048	N.D.	N.D.	0.35	1.6	N.D.
40316 PNM*	0.36	N.D.	N.D.	0.58	0.30	0.16	0.28	N.D.	0.74	2.7	0.054
40317 PNM	0.49	N.D.	0.12	0.31	0.20	0.064	0.076	N.D.	0.21	0.71	N.D.
40318 PNM	0.52	N.D.	0.045	0.61	0.24	0.085	0.043	N.D.	0.24	1.2	N.D.
40319 PNM	0.54	N.D.	N.D.	1.3	0.41	0.11	N.D.	N.D.	0.57	2.4	N.D.
40320 PNM*	0.41	N.D.	N.D.	0.99	0.47	0.20	0.20	N.D.	0.34	2.8	N.D.
40321 PNM*	0.76	N.D.	0.045	0.55	0.41	0.16	0.094	N.D.	0.34	11	N.D.
40322 PNM*	0.28	N.D.	0.12	3.0	0.84	0.29	0.092	N.D.	0.92	3.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40323 PNM	0.99	N.D.	N.D.	1.1	0.72	0.31	0.17	N.D.	0.28	5.8	0.11
40324 PNM*	0.93	N.D.	0.070	1.3	0.46	0.13	0.026	N.D.	0.48	3.2	0.047
40325 PNM	0.71	N.D.	N.D.	1.6	0.37	0.15	0.043	N.D.	0.40	5.9	N.D.
40326 PNM*	0.52	N.D.	N.D.	1.0	0.41	0.17	0.10	N.D.	0.45	2.6	N.D.
40327 PNM*	0.41	N.D.	N.D.	0.97	0.25	0.061	0.026	N.D.	0.91	1.7	N.D.
40328 PNM	0.42	N.D.	N.D.	0.51	0.37	0.26	0.40	N.D.	0.14	1.4	N.D.
40329 PNM*	0.50	N.D.	0.058	1.3	0.49	0.11	0.065	N.D.	0.45	1.8	N.D.
40330 PNM	0.68	N.D.	N.D.	1.8	0.57	0.19	0.26	N.D.	0.91	3.6	N.D.
40331 PNM	0.42	N.D.	N.D.	0.27	0.21	0.090	0.024	N.D.	0.096	0.79	N.D.
40332 PNM	0.95	N.D.	0.048	0.19	N.D.	0.051	0.026	N.D.	0.012	0.19	N.D.
40333 PNM	0.39	N.D.	0.024	1.2	0.38	0.13	0.093	N.D.	0.59	2.7	N.D.
40334 PNM*	0.51	N.D.	0.059	1.9	0.41	0.14	0.057	N.D.	1.2	3.6	0.047
40335 PNM	N.D.	N.D.	N.D.	1.0	0.55	0.15	0.078	N.D.	0.25	2.6	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40336 PNM	0.33	N.D.	N.D.	0.62	0.27	0.092	0.038	N.D.	0.25	1.7	N.D.
40338 PNM	1.1	N.D.	0.071	0.59	0.18	0.076	0.039	N.D.	0.28	0.87	N.D.
40342 PNM	0.53	N.D.	N.D.	0.51	0.28	0.16	0.062	N.D.	0.18	1.6	N.D.
40343 PNM	0.53	N.D.	0.017	0.65	0.29	0.093	0.059	N.D.	0.22	1.8	0.030
40344 PNM*	0.57	N.D.	N.D.	0.78	0.29	0.083	0.021	N.D.	0.35	1.3	N.D.
40345 PNM	0.49	N.D.	0.047	1.6	0.58	0.15	0.096	N.D.	1.3	3.0	N.D.
40346 PNM	0.80	N.D.	N.D.	1.1	0.40	0.11	N.D.	N.D.	0.34	2.5	0.055
40347 PNM	0.76	N.D.	N.D.	1.0	0.40	0.13	0.091	N.D.	0.98	3.1	N.D.
40349 PNM	0.76	N.D.	0.024	4.5	1.1	0.52	0.13	N.D.	1.0	2.0	N.D.
40350 PNM	0.42	N.D.	0.014	1.3	0.39	0.14	0.099	N.D.	1.2	3.7	0.070
40352 PNM	0.23	N.D.	0.013	0.49	0.24	0.065	0.018	N.D.	0.14	0.49	N.D.
40353 PNM•	0.55	N.D.	N.D.	2.2	0.59	0.28	N.D.	N.D.	1.3	4.0	N.D.
40354 PNM	0.67	N.D.	N.D.	0.64	0.57	0.35	0.41	N.D.	0.36	4.6	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40357 PNM	0.56	N.D.	0.11	4.3	1.7	0.73	0.27	N.D.	0.30	1.6	0.073
40358 PNM	0.60	N.D.	N.D.	0.59	0.20	0.077	N.D.	N.D.	0.29	0.74	N.D.
40359 PNM	0.56	N.D.	N.D.	1.2	0.35	0.12	0.035	N.D.	0.70	3.3	N.D.
40360 PNM	0.56	N.D.	0.057	0.86	0.35	0.16	0.043	N.D.	0.96	3.1	0.058
40361 PNM	N.D.	N.D.	N.D.	0.59	0.40	0.12	0.068	N.D.	0.46	3.5	0.045
40362 PNM	0.46	N.D.	N.D.	0.74	0.36	0.19	N.D.	N.D.	N.D.	1.7	0.11
40364 PNM	N.D.	N.D.	0.11	1.7	0.81	0.36	0.11	N.D.	0.50	5.0	N.D.
40365 PNM	0.52	N.D.	N.D.	1.0	0.37	0.15	0.12	N.D.	0.81	2.3	N.D.
40366 PNM	0.43	N.D.	N.D.	0.72	0.91	0.36	0.43	N.D.	0.25	4.4	N.D.
40369 PNM	0.57	N.D.	N.D.	0.66	0.28	N.D.	0.032	N.D.	0.72	1.1	N.D.
40371 PNM	0.63	N.D.	0.067	1.7	0.45	0.23	0.097	N.D.	1.1	5.1	0.066
40372 PNM	0.40	N.D.	N.D.	1.5	0.48	0.12	0.078	N.D.	0.62	2.4	N.D.
40375 PNM	0.47	N.D.	0.052	0.67	0.46	0.13	0.060	N.D.	N.D.	0.99	0.034

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40376 PNM	0.47	N.D.	N.D.	1.5	0.41	0.16	0.15	N.D.	2.2	4.1	N.D.
40378 PNM	N.D.	N.D.	N.D.	0.43	0.26	0.096	0.036	N.D.	N.D.	2.3	0.068
40379 PNM	0.65	N.D.	N.D.	0.47	0.29	N.D.	0.045	N.D.	1.7	2.8	N.D.
40381 PNM	0.48	N.D.	N.D.	0.37	0.23	0.10	0.032	N.D.	N.D.	1.5	N.D.
40382 PNM*	0.86	N.D.	N.D.	1.7	0.46	0.17	0.16	N.D.	1.9	5.4	N.D.
40384 PNM*	0.91	N.D.	0.052	1.0	0.42	0.22	0.11	N.D.	0.51	2.4	N.D.
40386 PNM	N.D.	N.D.	0.078	1.8	0.44	0.14	0.037	N.D.	1.3	2.1	N.D.
40388 PNM•	0.96	N.D.	0.13	0.69	0.51	0.15	0.044	N.D.	0.41	3.1	N.D.
40390 PNM	N.D.	N.D.	0.057	1.2	0.97	0.28	0.17	N.D.	0.83	5.0	N.D.
40392 PNM•	0.80	N.D.	N.D.	1.8	0.63	0.21	0.065	N.D.	0.66	4.2	N.D.
40393 PNM	0.46	N.D.	N.D.	1.1	0.42	0.17	0.13	N.D.	0.50	2.4	N.D.
40395 PNM	N.D.	N.D.	N.D.	0.50	0.31	0.11	0.040	N.D.	N.D.	2.1	N.D.
40396 PNM	0.63	N.D.	N.D.	2.0	0.66	0.21	0.14	N.D.	1.1	5.3	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40397 PNM•	0.39	N.D.	N.D.	0.64	0.21	0.10	N.D.	N.D.	0.55	1.1	N.D.
40399 PNM	0.79	N.D.	0.060	0.81	0.59	0.23	0.14	N.D.	0.20	3.0	N.D.
40401 PNM	0.59	N.D.	0.10	1.5	0.34	0.094	N.D.	N.D.	0.26	1.6	N.D.
40405 PNM*	0.64	N.D.	N.D.	0.77	0.32	0.12	0.043	N.D.	0.59	1.2	N.D.
40406 PNM	N.D.	N.D.	N.D.	0.58	0.61	0.18	0.16	N.D.	2.3	2.0	N.D.
40409 PNM	N.D.	N.D.	N.D.	0.48	0.17	N.D.	N.D.	N.D.	N.D.	1.4	N.D.
40411 PNM*	0.46	N.D.	0.061	0.99	0.38	0.090	0.036	N.D.	0.85	2.4	N.D.
40412 PNM*	0.56	N.D.	0.066	0.42	0.23	0.088	0.039	N.D.	0.31	1.1	N.D.
40413 PNM	0.56	N.D.	N.D.	0.48	0.24	0.094	N.D.	N.D.	0.80	2.9	0.049
40415 PNM•	0.48	N.D.	0.051	0.98	0.32	0.091	0.045	N.D.	1.5	1.7	N.D.
40416 PNM	0.20	N.D.	N.D.	0.35	0.23	N.D.	0.042	N.D.	N.D.	1.3	N.D.
40417 PNM	0.46	N.D.	0.066	2.4	0.49	0.18	0.068	N.D.	0.68	2.9	N.D.
40418 PNM	0.98	N.D.	N.D.	0.48	0.20	0.066	N.D.	N.D.	N.D.	0.96	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40419 PNM	0.51	N.D.	N.D.	1.8	0.47	0.16	0.037	N.D.	0.39	3.6	N.D.
40420 PNM	0.32	N.D.	N.D.	0.82	0.38	0.15	0.12	N.D.	0.56	2.4	N.D.
40421 PNM	0.58	N.D.	N.D.	0.72	0.28	0.11	N.D.	N.D.	N.D.	0.90	N.D.
40422 PNM	0.26	N.D.	N.D.	1.6	0.34	0.13	N.D.	N.D.	0.74	3.0	N.D.
40424 PNM	0.37	N.D.	N.D.	0.68	0.42	0.15	0.30	N.D.	0.91	1.7	N.D.
40425 PNM	0.45	N.D.	N.D.	0.29	0.27	0.086	0.049	N.D.	N.D.	0.28	N.D.
40428 PNM*	0.31	N.D.	N.D.	0.78	0.28	0.11	0.073	N.D.	0.40	2.2	N.D.
40429 PNM*	0.37	N.D.	0.061	0.61	0.25	0.053	0.015	N.D.	0.25	0.54	N.D.
40430 PNM	0.50	N.D.	N.D.	0.70	0.32	0.13	0.11	N.D.	0.44	1.7	N.D.
40432 PNM•	0.51	N.D.	0.065	2.1	0.77	0.34	0.10	N.D.	0.49	2.9	0.065
40433 PNM	N.D.	N.D.	0.068	1.0	0.33	N.D.	N.D.	N.D.	0.44	2.3	N.D.
40434 PNM•	0.49	N.D.	N.D.	0.73	0.59	0.36	0.39	N.D.	0.21	4.1	N.D.
40436 PNM	0.84	N.D.	N.D.	1.3	0.50	0.21	N.D.	N.D.	0.56	3.8	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40438 PNM	0.28	N.D.	0.039	0.36	0.20	0.080	0.047	N.D.	N.D.	0.99	N.D.
40439 PNM	N.D.	N.D.	0.037	0.63	0.31	0.093	N.D.	N.D.	0.88	1.9	N.D.
40440 PNM	0.61	N.D.	N.D.	0.97	0.40	0.11	0.074	N.D.	0.30	1.6	N.D.
40441 PNM*	0.73	0.018	0.061	2.5	0.64	0.31	0.062	N.D.	1.0	3.0	N.D.
40442 PNM	0.36	N.D.	0.078	0.83	0.39	0.17	0.14	N.D.	N.D.	1.5	N.D.
40443 PNM	0.15	N.D.	N.D.	0.71	0.17	0.079	0.028	N.D.	0.53	1.0	N.D.
40444 PNM	0.51	N.D.	N.D.	0.54	0.33	0.13	0.046	N.D.	0.69	2.3	N.D.
40445 PNM*	0.40	N.D.	0.082	1.7	0.67	0.24	0.061	N.D.	0.51	1.7	N.D.
40446 PNM	0.61	N.D.	0.066	0.64	0.28	0.12	0.044	N.D.	N.D.	1.4	N.D.
40447 PNM*•	0.99	N.D.	0.051	0.48	0.30	0.14	0.15	N.D.	0.67	3.0	N.D.
40449 PNM*	0.59	N.D.	N.D.	0.99	0.24	0.094	0.054	N.D.	1.0	1.9	N.D.
40451 PNM*•	0.83	N.D.	0.046	0.27	0.23	0.076	0.070	N.D.	0.35	0.93	0.035
40453 PNM	0.26	N.D.	0.033	1.4	0.37	0.11	0.032	N.D.	0.32	1.4	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40454 PNM*•	0.91	N.D.	N.D.	0.70	0.31	0.11	0.050	N.D.	0.47	1.6	0.086
40455 PNM	0.45	N.D.	0.031	0.95	0.68	0.34	0.33	N.D.	0.55	3.1	N.D.
40456 PNM*•	0.32	N.D.	0.090	1.0	0.31	0.11	0.067	N.D.	0.44	1.3	N.D.
40457 PNM	0.43	N.D.	N.D.	0.21	0.22	N.D.	0.089	N.D.	N.D.	0.92	N.D.
40458 PNM*	2.2	N.D.	N.D.	0.81	0.67	0.14	0.049	N.D.	0.41	1.8	N.D.
40460 PNM*	0.41	N.D.	N.D.	0.44	0.64	0.23	0.30	N.D.	0.27	2.0	N.D.
40461 PNM*•	0.36	N.D.	0.027	1.1	0.34	0.12	0.025	N.D.	0.21	1.3	N.D.
40462 PNM	0.23	N.D.	N.D.	0.82	0.26	0.12	0.061	N.D.	0.69	2.3	N.D.
40463 PNM	0.72	N.D.	0.060	1.7	0.53	0.22	0.14	N.D.	2.2	8.8	N.D.
40464 PNM*	0.56	N.D.	0.012	0.94	0.41	0.19	0.17	N.D.	0.54	3.3	N.D.
40465 PNM*	0.86	0.009	N.D.	2.2	0.42	0.18	0.085	N.D.	2.2	4.0	N.D.
40466 PNM*	0.78	N.D.	N.D.	1.4	0.43	0.11	0.029	N.D.	0.84	4.1	N.D.
40467 PNM*	0.88	N.D.	N.D.	0.37	0.33	0.11	0.047	N.D.	0.46	3.4	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40468 PNM	0.37	N.D.	N.D.	0.36	0.43	0.16	0.13	N.D.	0.32	1.8	N.D.
40469 PNM*	1.3	N.D.	N.D.	0.45	0.29	0.10	0.036	N.D.	0.14	1.6	N.D.
40470 PNM*	0.41	N.D.	0.049	0.41	0.19	N.D.	N.D.	N.D.	0.22	0.88	N.D.
40471 PNM	0.46	N.D.	N.D.	0.67	0.34	0.15	0.12	N.D.	0.89	1.7	N.D.
40472 PNM	N.D.	N.D.	N.D.	0.16	0.96	0.37	0.28	N.D.	N.D.	9.3	N.D.
40474 PNM*	0.76	N.D.	N.D.	0.70	0.65	0.12	0.096	N.D.	0.32	1.7	N.D.
40475 PNM•	0.18	N.D.	0.083	1.4	0.48	0.14	N.D.	N.D.	0.88	2.2	0.068
40476 PNM	0.46	N.D.	N.D.	1.6	2.1	0.19	0.21	N.D.	0.97	1.4	N.D.
40478 PNM*•	0.52	0.040	0.031	0.43	0.39	0.11	0.057	N.D.	0.61	1.0	N.D.
40480 PNM*	0.97	N.D.	N.D.	1.6	0.57	0.18	0.11	N.D.	0.97	2.9	N.D.
40481 PNM	0.45	N.D.	N.D.	1.6	0.51	0.19	N.D.	N.D.	1.2	3.4	N.D.
40482 PNM	N.D.	N.D.	N.D.	0.56	0.24	0.13	0.11	N.D.	0.47	2.1	N.D.
40483 PNM	0.17	N.D.	N.D.	1.2	0.35	N.D.	0.039	N.D.	1.9	2.8	0.067

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40485 PNM*	0.68	N.D.	0.022	0.73	0.26	0.091	0.029	N.D.	1.7	1.1	N.D.
40489 PNM•	0.76	N.D.	N.D.	1.5	0.47	0.12	N.D.	N.D.	0.40	8.2	N.D.
40490 PNM*•	0.25	N.D.	0.014	0.88	0.32	0.12	0.052	N.D.	0.17	1.3	N.D.
40491 PNM*	0.33	0.018	N.D.	1.9	0.57	0.21	0.11	N.D.	0.70	2.0	0.041
40492 PNM*	0.78	N.D.	N.D.	0.69	0.33	0.079	0.021	N.D.	0.38	1.9	N.D.
40494 PNM	0.44	N.D.	N.D.	1.3	0.51	0.20	0.13	N.D.	0.83	3.1	N.D.
40495 PNM	0.62	N.D.	0.029	1.4	0.41	0.13	0.045	N.D.	0.33	2.3	N.D.
40496 PNM	0.20	N.D.	N.D.	0.54	0.20	0.069	N.D.	N.D.	0.16	0.94	N.D.
40497 PNM	0.18	N.D.	N.D.	0.36	0.41	0.097	0.078	N.D.	N.D.	1.7	N.D.
40498 PNM	0.17	N.D.	N.D.	0.42	0.24	0.13	0.12	N.D.	0.47	0.94	N.D.
40499 PNM*	0.51	N.D.	N.D.	1.2	0.67	0.29	0.22	N.D.	1.4	3.3	0.049
40500 PNM*	0.60	N.D.	N.D.	1.0	0.37	0.12	0.075	N.D.	2.3	3.2	N.D.
40504 PNM	0.49	N.D.	N.D.	1.3	0.32	0.10	0.048	N.D.	2.7	3.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40505 PNM	0.29	N.D.	N.D.	0.75	0.22	0.082	0.061	N.D.	N.D.	2.0	N.D.
40506 PNM	0.21	N.D.	N.D.	0.80	0.32	0.095	0.046	N.D.	0.28	2.4	N.D.
40507 PNM	0.31	N.D.	N.D.	0.96	0.36	0.15	0.039	N.D.	0.45	2.0	N.D.
40508 PNM	0.27	N.D.	N.D.	0.56	0.20	0.14	N.D.	N.D.	N.D.	1.3	N.D.
40514 PNM*	0.45	N.D.	N.D.	1.7	0.67	0.17	N.D.	N.D.	N.D.	2.0	N.D.
40517 PNM	0.37	N.D.	N.D.	1.4	0.50	0.15	0.067	N.D.	0.76	2.1	N.D.
40518 PNM	0.63	N.D.	N.D.	1.2	0.65	0.11	0.048	N.D.	0.37	1.3	N.D.
40521 PNM	0.14	N.D.	N.D.	1.3	0.35	0.15	0.13	N.D.	0.57	2.0	N.D.
40522 PNM•	0.25	N.D.	N.D.	1.1	0.42	0.080	0.038	N.D.	0.41	2.4	N.D.
40523 PNM*	0.42	N.D.	0.036	1.8	0.48	0.17	0.11	N.D.	0.48	4.2	0.11
40525 PNM*	0.41	N.D.	N.D.	0.55	0.22	0.097	N.D.	N.D.	0.52	1.3	N.D.
40526 PNM	0.24	N.D.	N.D.	0.31	0.27	0.11	N.D.	N.D.	0.12	0.78	N.D.
40527 PNM	0.24	N.D.	0.086	0.44	0.21	0.094	N.D.	N.D.	N.D.	1.7	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40528 PNM	0.44	N.D.	N.D.	0.84	0.26	0.094	0.047	N.D.	0.32	2.1	N.D.
40529 PNM	N.D.	N.D.	0.092	0.99	0.31	0.13	0.045	N.D.	0.89	2.8	N.D.
40530 PNM*	0.97	N.D.	N.D.	1.1	0.34	0.13	0.13	N.D.	N.D.	0.84	N.D.
40532 PNM*•	0.78	N.D.	0.047	0.44	0.23	0.086	0.027	N.D.	0.30	0.96	0.036
40533 PNM	0.46	N.D.	N.D.	0.29	0.37	0.21	0.27	N.D.	0.31	2.8	N.D.
40535 PNM	0.37	N.D.	N.D.	1.1	0.45	0.19	0.059	N.D.	0.60	4.8	0.039
40537 PNM•	0.32	N.D.	N.D.	0.49	0.39	0.14	N.D.	N.D.	0.25	0.83	N.D.
40538 PNM	0.25	N.D.	N.D.	0.64	0.50	0.10	0.062	N.D.	N.D.	1.3	N.D.
40539 PNM	0.38	N.D.	N.D.	0.98	0.25	N.D.	0.057	N.D.	1.2	1.6	N.D.
40541 PNM*	0.94	N.D.	N.D.	0.96	0.39	0.12	0.042	N.D.	0.90	3.5	N.D.
40542 PNM	0.36	0.036	N.D.	1.0	0.34	N.D.	0.095	N.D.	0.32	2.2	N.D.
40543 PNM*	1.0	N.D.	0.053	1.2	0.36	0.14	0.084	N.D.	0.55	2.2	N.D.
40544 PNM*	0.48	N.D.	0.10	0.91	0.25	0.10	0.082	N.D.	0.32	1.9	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40545 PNM	0.46	N.D.	0.030	0.45	0.23	N.D.	0.054	N.D.	0.30	0.72	N.D.
40547 PNM*	0.83	N.D.	0.31	0.68	0.36	0.11	0.059	N.D.	2.8	3.2	0.034
40548 PNM*	0.62	N.D.	0.24	3.0	0.67	0.31	0.047	N.D.	0.14	1.4	0.029
40549 PNM	0.33	N.D.	N.D.	1.9	0.54	0.15	0.092	N.D.	5.9	4.4	N.D.
40551 PNM*	0.47	0.017	0.24	1.5	0.56	0.13	0.055	N.D.	0.57	2.3	N.D.
40552 PNM*	0.51	N.D.	0.051	1.2	0.32	0.11	0.075	N.D.	0.50	1.6	N.D.
40554 PNM	0.64	N.D.	N.D.	0.44	0.25	0.11	0.13	N.D.	0.44	1.8	N.D.
40556 PNM•	0.30	N.D.	N.D.	0.46	0.28	0.093	0.14	N.D.	0.58	1.8	0.032
40557 PNM•	0.30	N.D.	N.D.	0.54	0.23	0.099	0.080	N.D.	0.77	1.1	N.D.
40558 PNM	0.88	N.D.	N.D.	3.5	0.35	0.12	0.13	N.D.	0.47	2.0	N.D.
40559 PNM•	0.23	N.D.	N.D.	0.68	0.32	0.12	0.068	N.D.	0.36	1.8	0.050
40560 PNM	0.19	N.D.	N.D.	0.98	0.45	0.13	0.054	N.D.	0.39	3.5	N.D.
40561 PNM	0.67	N.D.	0.23	0.84	0.38	0.11	0.053	N.D.	0.46	1.5	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40563 PNM	0.74	N.D.	N.D.	1.5	0.52	0.24	0.088	N.D.	0.31	2.2	N.D.
40564 PNM*	0.46	0.027	0.18	1.1	0.31	0.089	0.021	N.D.	0.45	2.6	N.D.
40566 PNM	0.26	N.D.	N.D.	0.43	0.21	0.10	0.049	N.D.	0.21	1.4	N.D.
40568 PNM*	0.52	N.D.	0.27	2.1	0.65	0.27	0.090	N.D.	0.46	5.5	N.D.
40571 PNM	N.D.	N.D.	N.D.	2.4	0.74	0.24	0.072	N.D.	0.49	3.2	N.D.
40573 PNM•	0.77	N.D.	N.D.	1.6	0.81	0.20	0.062	N.D.	7.2	9.5	N.D.
40575 PNM	0.32	N.D.	N.D.	0.37	0.23	0.081	N.D.	N.D.	0.20	1.4	N.D.
40576 PNM	0.15	N.D.	N.D.	1.9	0.36	0.097	0.049	N.D.	0.51	3.6	0.028
40579 PNM*•	0.48	N.D.	0.15	0.77	0.57	0.15	0.11	N.D.	0.46	1.8	N.D.
40580 PNM•	0.36	N.D.	N.D.	0.30	0.29	0.067	0.050	N.D.	0.26	0.79	N.D.
40583 PNM	0.58	N.D.	N.D.	0.66	0.31	0.16	0.050	N.D.	1.8	2.4	N.D.
40584 PNM	0.32	N.D.	N.D.	0.57	0.25	N.D.	0.048	N.D.	N.D.	0.72	N.D.
40586 PNM*•	0.29	N.D.	0.12	0.80	0.94	0.23	0.23	N.D.	0.37	3.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40587 PNM*	0.42	N.D.	0.19	1.4	0.46	0.088	0.072	N.D.	0.58	3.1	0.027
40588 PNM	0.32	N.D.	N.D.	0.57	0.33	0.14	0.11	N.D.	N.D.	1.6	0.023
40589 PNM*	0.49	N.D.	0.015	0.28	0.27	N.D.	0.059	N.D.	0.24	0.88	N.D.
40590 PNM	0.19	N.D.	0.062	1.2	0.34	0.12	0.11	N.D.	0.89	3.4	0.032
40592 PNM	0.38	N.D.	N.D.	0.35	0.25	0.088	0.082	N.D.	0.38	0.76	N.D.
40593 PNM	0.09	N.D.	N.D.	0.53	0.36	0.10	0.046	N.D.	0.52	1.6	N.D.
40594 PNM*	0.45	N.D.	0.024	0.44	0.26	0.086	0.065	N.D.	0.25	1.3	0.059
40600 PNM	0.44	N.D.	0.064	2.2	1.0	0.47	0.14	N.D.	N.D.	1.0	N.D.
40602 PNM*	0.54	N.D.	N.D.	0.41	0.23	0.082	0.042	N.D.	0.37	0.67	N.D.
40603 PNM	0.14	N.D.	N.D.	0.44	0.23	0.090	0.050	N.D.	1.2	2.7	N.D.
40604 PNM	0.37	N.D.	N.D.	3.2	0.61	0.19	0.076	N.D.	0.55	6.6	N.D.
40605 PNM*•	0.58	N.D.	0.039	0.73	0.38	0.079	0.037	N.D.	0.18	1.3	N.D.
40607 PNM*	0.62	N.D.	0.016	2.2	0.82	0.25	0.11	N.D.	1.3	2.8	0.060

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40611 PNM*•	0.72	0.012	0.028	0.95	0.33	0.098	0.084	N.D.	2.3	1.6	N.D.
40612 PNM	N.D.	0.17	N.D.	0.78	N.D.	0.19	0.10	N.D.	0.68	4.1	N.D.
40613 PNM	0.34	N.D.	N.D.	3.6	0.51	0.19	0.23	N.D.	0.72	3.0	N.D.
40614 PNM*	0.25	N.D.	N.D.	0.66	0.29	0.12	0.12	N.D.	0.092	0.98	N.D.
40616 PNM*	0.50	0.013	0.034	1.3	0.57	0.21	0.17	N.D.	1.5	2.6	N.D.
40620 PNM	N.D.	N.D.	N.D.	1.0	0.38	0.12	0.071	N.D.	0.31	1.7	N.D.
40623 PNM	0.20	N.D.	0.059	1.3	0.34	0.11	0.034	N.D.	0.31	2.5	N.D.
40625 PNM	0.62	N.D.	N.D.	0.99	0.37	0.14	0.074	N.D.	0.39	2.8	N.D.
40628 PNM	0.18	N.D.	N.D.	2.1	0.57	0.20	0.062	N.D.	0.63	3.4	N.D.
40629 PNM	0.46	N.D.	0.069	7.1	2.6	1.4	0.38	N.D.	1.0	3.9	N.D.
40630 PNM•	0.40	N.D.	0.063	1.3	0.50	0.27	0.077	N.D.	1.7	2.3	N.D.
40631 PNM	N.D.	N.D.	0.067	2.0	0.52	0.11	0.045	N.D.	0.81	2.6	N.D.
40632 PNM	0.31	N.D.	N.D.	1.3	0.59	0.16	0.099	N.D.	0.61	3.7	0.073

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40633 PNM*	0.25	N.D.	N.D.	0.52	0.34	0.067	0.064	N.D.	N.D.	0.63	N.D.
40644 PNM	0.24	N.D.	N.D.	0.48	0.20	0.037	0.030	N.D.	N.D.	0.26	N.D.
40646 PNM*	0.65	N.D.	0.018	1.1	0.37	0.15	0.094	N.D.	1.0	2.7	N.D.
40647 PNM	0.25	N.D.	N.D.	0.72	0.31	0.17	0.19	N.D.	N.D.	1.7	N.D.
40648 PNM	0.23	N.D.	N.D.	1.3	0.52	0.19	0.14	N.D.	0.69	2.0	N.D.
40649 PNM	0.30	N.D.	N.D.	0.82	0.34	N.D.	N.D.	N.D.	0.31	2.1	N.D.
40650 PNM	0.60	N.D.	N.D.	1.0	0.42	0.13	0.065	N.D.	0.79	2.5	N.D.
40651 PNM	0.37	N.D.	N.D.	0.35	0.29	0.096	0.077	N.D.	0.38	1.6	N.D.
40652 PNM*•	0.94	N.D.	0.012	0.76	0.37	0.12	0.075	N.D.	0.55	1.7	N.D.
40653 PNM	0.40	N.D.	N.D.	1.6	0.43	N.D.	0.054	N.D.	0.98	5.4	0.062
40654 PNM	0.25	N.D.	0.044	2.0	0.40	0.22	N.D.	N.D.	N.D.	2.7	N.D.
40656 PNM•	0.42	N.D.	N.D.	0.93	0.33	0.12	0.073	N.D.	1.7	4.5	N.D.
40659 PNM	0.18	N.D.	0.13	1.0	0.75	0.16	0.080	N.D.	N.D.	1.2	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40661 PNM•	0.42	N.D.	N.D.	0.94	0.23	0.077	0.028	N.D.	0.99	0.86	N.D.
40662 PNM*	1.3	N.D.	0.032	2.0	0.53	0.20	0.14	N.D.	1.8	3.6	N.D.
40663 PNM	0.26	N.D.	N.D.	0.42	0.23	N.D.	N.D.	N.D.	0.53	3.4	0.025
40664 PNM	0.54	N.D.	N.D.	0.83	0.41	0.21	0.045	N.D.	0.17	1.2	N.D.
40665 PNM	N.D.	N.D.	N.D.	0.75	0.30	0.083	0.051	N.D.	3.2	2.7	0.022
40667 PNM	0.66	N.D.	N.D.	1.2	0.44	0.15	0.044	N.D.	0.39	5.8	0.064
40668 PNM	0.34	N.D.	N.D.	2.0	0.52	0.15	0.096	N.D.	1.9	3.9	N.D.
40669 PNM	N.D.	N.D.	0.10	2.4	0.76	0.25	0.067	N.D.	1.2	4.2	N.D.
40670 PNM*	0.91	N.D.	0.080	2.8	0.93	0.48	0.12	N.D.	0.43	2.4	N.D.
40671 PNM	0.19	N.D.	N.D.	1.7	0.51	0.20	0.071	N.D.	2.2	1.4	N.D.
40673 PNM	N.D.	N.D.	N.D.	0.46	0.47	N.D.	0.095	N.D.	0.38	3.8	N.D.
40674 PNM	N.D.	N.D.	N.D.	1.5	0.33	0.11	N.D.	N.D.	0.50	2.3	N.D.
40676 PNM	0.12	N.D.	N.D.	1.2	0.43	0.14	0.13	N.D.	0.55	2.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40677 PNM	0.38	N.D.	N.D.	0.85	0.28	N.D.	0.033	N.D.	0.45	1.4	N.D.
40680 PNM	0.38	N.D.	N.D.	1.6	0.49	0.15	0.11	N.D.	0.60	3.7	N.D.
40683 PNM	1.3	N.D.	N.D.	1.0	0.25	0.092	0.051	N.D.	0.67	1.5	N.D.
40686 PNM	0.56	N.D.	N.D.	0.43	0.27	0.16	0.11	N.D.	N.D.	1.3	N.D.
40688 PNM	0.18	N.D.	N.D.	1.1	0.51	0.14	0.078	N.D.	0.30	2.6	N.D.
40689 PNM	0.46	N.D.	N.D.	0.51	0.47	0.14	0.062	N.D.	0.43	2.5	N.D.
40690 PNM	0.54	N.D.	N.D.	0.50	0.27	0.11	0.033	N.D.	0.35	2.1	N.D.
40691 PNM	0.59	N.D.	N.D.	1.9	0.51	0.18	0.15	N.D.	1.2	4.0	N.D.
40692 PNM	0.22	N.D.	N.D.	0.87	0.38	N.D.	0.13	N.D.	0.39	1.7	N.D.
40693 PNM	0.25	N.D.	N.D.	0.91	0.34	0.13	0.054	N.D.	1.1	4.9	N.D.
40694 PNM	1.5	N.D.	N.D.	1.9	0.62	0.16	0.080	N.D.	1.3	2.8	N.D.
40695 PNM	0.25	N.D.	N.D.	1.1	0.35	N.D.	0.086	N.D.	0.39	1.8	N.D.
40696 PNM	0.35	N.D.	N.D.	0.84	0.34	0.12	0.091	N.D.	0.44	2.2	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40697 PNM	0.41	N.D.	N.D.	0.65	0.25	0.13	0.086	N.D.	1.5	2.8	N.D.
40698 PNM	N.D.	N.D.	N.D.	1.0	0.34	0.11	0.076	0.016	0.89	2.2	N.D.
40699 PNM	0.39	N.D.	N.D.	4.0	1.3	0.52	0.12	N.D.	0.35	1.8	N.D.
40704 PNM	0.13	N.D.	N.D.	0.78	0.50	0.13	0.13	N.D.	0.29	1.4	N.D.
40705 PNM	0.24	N.D.	N.D.	0.44	0.39	0.17	0.13	N.D.	0.49	1.9	N.D.
40706 PNM	0.39	N.D.	0.060	2.3	0.71	0.18	0.037	N.D.	0.73	2.1	N.D.
40707 PNM	0.30	N.D.	N.D.	0.97	0.31	0.19	0.087	N.D.	1.1	3.2	N.D.
40708 PNM	0.22	N.D.	N.D.	0.50	4.0	1.4	0.37	N.D.	N.D.	21	0.34
40709 PNM	N.D.	N.D.	N.D.	3.8	0.88	0.42	0.13	N.D.	24	5.5	N.D.
40710 PNM•	0.13	N.D.	N.D.	0.38	0.30	0.12	0.091	N.D.	0.47	1.5	N.D.
40711 PNM	0.69	N.D.	N.D.	1.1	0.60	0.089	0.081	N.D.	0.46	1.3	0.042
40712 PNM	0.34	N.D.	N.D.	0.41	0.24	0.13	0.055	N.D.	N.D.	1.1	N.D.
40713 PNM	0.29	N.D.	0.049	0.82	0.38	0.18	0.13	N.D.	0.51	2.8	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40718 PNM	0.37	N.D.	N.D.	1.4	0.35	0.11	0.074	N.D.	0.41	2.5	N.D.
40719 PNM*•	0.51	N.D.	0.018	0.39	0.26	0.11	0.14	N.D.	N.D.	0.79	N.D.
40720 PNM	0.31	N.D.	N.D.	1.2	0.33	0.11	0.048	N.D.	0.98	2.4	N.D.
40722 PNM	0.71	N.D.	0.044	0.86	0.34	0.098	0.062	N.D.	0.34	2.5	0.048
40723 PNM	0.18	N.D.	N.D.	1.5	0.33	0.12	0.040	N.D.	0.55	1.4	N.D.
40724 PNM	0.15	N.D.	N.D.	0.79	0.29	0.098	0.097	N.D.	0.28	1.3	N.D.
40725 PNM	0.27	N.D.	0.048	0.81	0.54	0.20	0.16	N.D.	0.50	5.9	0.066
40726 PNM	N.D.	N.D.	N.D.	0.27	0.17	0.069	0.055	N.D.	N.D.	0.65	N.D.
40727 PNM	0.48	N.D.	N.D.	0.66	0.23	0.091	0.068	N.D.	0.18	0.89	N.D.
40730 PNM	0.27	N.D.	N.D.	0.28	0.16	0.057	0.026	N.D.	N.D.	1.2	N.D.
40731 PNM	0.22	N.D.	N.D.	0.18	0.16	0.095	0.048	N.D.	0.14	1.1	N.D.
40732 PNM	0.30	N.D.	N.D.	0.69	0.42	0.15	0.16	N.D.	0.20	1.4	N.D.
40739 PNM	0.30	N.D.	0.049	2.2	0.47	0.18	0.046	N.D.	0.42	3.3	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40740 PNM	0.26	N.D.	N.D.	0.96	0.44	0.17	0.10	N.D.	1.4	3.2	N.D.
40745 PNM	0.61	0.16	N.D.	0.35	0.22	0.12	0.062	N.D.	0.26	1.0	N.D.
40792 PNM	0.63	0.16	N.D.	0.87	0.91	0.38	0.34	N.D.	0.31	5.6	N.D.
40834 PNM	0.98	N.D.	N.D.	0.30	0.13	N.D.	N.D.	N.D.	N.D.	0.59	N.D.
40890 PNM	0.85	0.16	N.D.	0.63	0.25	0.11	0.051	N.D.	0.28	1.1	N.D.
40891 PNM	0.81	0.12	0.034	0.49	0.43	0.22	0.15	N.D.	0.33	2.9	N.D.
40893 PNM	0.63	N.D.	N.D.	1.1	0.42	N.D.	0.14	N.D.	1.9	2.9	N.D.
40894 PNM	0.38	N.D.	N.D.	0.61	0.31	0.14	0.18	N.D.	0.70	0.85	N.D.
40925 PNM	0.71	N.D.	0.071	1.6	0.36	N.D.	0.057	N.D.	0.42	2.4	N.D.
40931 PNM	0.98	0.12	N.D.	0.84	N.D.	0.10	0.033	N.D.	0.68	2.7	N.D.
40955 PNM	0.87	N.D.	N.D.	0.76	0.34	0.13	0.11	N.D.	0.17	1.7	N.D.
41077 PNM	1.0	N.D.	N.D.	0.86	0.37	0.13	0.044	N.D.	0.95	2.3	N.D.

Appendix B: Concentrations of 8:2 FTUCA, FOSAs, and FOSEs in maternal plasma during pregnancy (ng/mL).

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40074 PNM*	N.D.	N.D.	N.D.	0.058	0.012	0.040
40091 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40110 PNM*•	N.D.	N.D.	N.D.	0.082	0.004	0.046
40124 PNM*	N.D.	N.D.	N.D.	0.001	N.D.	0.003
40134 PNM*	N.D.	0.010	N.D.	N.D.	N.D.	N.D.
40138 PNM*•	0.006	0.014	N.D.	0.022	N.D.	0.022
40139 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40140 PNM*	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40142 PNM*	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40143 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40144 PNM*•	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40145 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40146 PNM*	N.D.	N.D.	N.D.	0.015	0.012	N.D.
40147 PNM*	N.D.	N.D.	N.D.	0.005	0.005	0.002
40148 PNM*	N.D.	N.D.	0.020	0.019	0.011	0.013
40149 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40150 PNM*	N.D.	N.D.	0.010	N.D.	0.002	N.D.
40151 PNM	N.D.	N.D.	N.D.	0.033	N.D.	N.D.
40156 PNM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40157 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40158 PNM*	N.D.	N.D.	N.D.	0.013	0.009	N.D.
40159 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40160 PNM	N.D.	0.016	N.D.	N.D.	N.D.	N.D.
40161 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40162 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40163 PNM	N.D.	0.010	N.D.	N.D.	N.D.	N.D.
40164 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40165 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40166 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40167 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	0.003
40168 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40169 PNM*	N.D.	0.008	N.D.	0.011	0.009	0.004
40170 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40171 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	0.001
40172 PNM*	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40173 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40175 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40176 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40177 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40178 PNM*	N.D.	N.D.	N.D.	0.026	0.014	0.005

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40179 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40180 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40181 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40185 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40186 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40187 PNM*	N.D.	N.D.	N.D.	0.018	0.011	N.D.
40188 PNM*	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40190 PNM*	N.D.	N.D.	N.D.	0.013	0.008	0.005
40192 PNM*	N.D.	N.D.	N.D.	N.D.	0.012	0.002
40193 PNM*	N.D.	N.D.	N.D.	N.D.	0.016	N.D.
40194 PNM*	N.D.	N.D.	N.D.	0.004	0.008	N.D.
40195 PNM*•	N.D.	N.D.	N.D.	N.D.	0.013	N.D.
40196 PNM*•	N.D.	N.D.	N.D.	0.008	N.D.	N.D.
40197 PNM*	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40198 PNM*	N.D.	N.D.	N.D.	N.D.	0.012	N.D.
40203 PNM*	N.D.	0.024	N.D.	0.003	0.013	N.D.
40204 PNM	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40205 PNM*	N.D.	0.24	N.D.	N.D.	N.D.	N.D.
40206 PNM*	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40209 PNM*	N.D.	N.D.	N.D.	0.004	0.013	N.D.
40210 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40211 PNM*•	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40212 PNM	N.D.	N.D.	N.D.	N.D.	0.012	N.D.
40213 PNM	N.D.	N.D.	N.D.	N.D.	0.014	N.D.
40215 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40218 PNM*	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40224 PNM	N.D.	N.D.	N.D.	0.015	0.007	N.D.
40225 PNM*	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40226 PNM	N.D.	N.D.	N.D.	N.D.	0.006	0.004
40227 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40228 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40232 PNM*	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40235 PNM*	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40241 PNM	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40243 PNM*	N.D.	N.D.	N.D.	0.024	N.D.	0.024
40244 PNM*•	N.D.	N.D.	N.D.	N.D.	0.015	N.D.
40245 PNM*	N.D.	N.D.	N.D.	N.D.	0.012	N.D.
40246 PNM*	N.D.	N.D.	N.D.	0.008	0.005	N.D.
40247 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40248 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	0.001
40249 PNM	N.D.	N.D.	N.D.	0.003	0.003	N.D.
40250 PNM*	N.D.	N.D.	N.D.	N.D.	0.004	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40252 PNM*•	N.D.	N.D.	N.D.	N.D.	0.010	N.D.
40254 PNM*•	N.D.	0.023	N.D.	N.D.	0.007	N.D.
40255 PNM*	N.D.	N.D.	N.D.	N.D.	0.015	N.D.
40256 PNM*	N.D.	0.024	N.D.	N.D.	0.010	N.D.
40257 PNM*	N.D.	N.D.	N.D.	N.D.	0.020	N.D.
40258 PNM*	N.D.	0.024	N.D.	N.D.	N.D.	N.D.
40259 PNM*	N.D.	N.D.	N.D.	N.D.	0.010	N.D.
40260 PNM	N.D.	N.D.	N.D.	N.D.	0.20	N.D.
40261 PNM*	N.D.	0.027	N.D.	N.D.	0.010	N.D.
40264 PNM*	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40265 PNM*	N.D.	N.D.	N.D.	N.D.	0.021	N.D.
40268 PNM*	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40269 PNM*	N.D.	N.D.	N.D.	N.D.	0.010	N.D.
40271 PNM*	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40272 PNM*	N.D.	N.D.	N.D.	0.039	N.D.	0.030
40273 PNM*	N.D.	N.D.	0.023	0.047	0.031	0.036
40274 PNM*	N.D.	N.D.	N.D.	N.D.	0.002	0.002
40275 PNM	N.D.	N.D.	N.D.	N.D.	0.010	N.D.
40276 PNM*	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40279 PNM*	N.D.	N.D.	N.D.	N.D.	0.005	0.002
40280 PNM*	N.D.	0.017	N.D.	N.D.	N.D.	0.001

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40284 PNM*	N.D.	N.D.	N.D.	N.D.	0.001	0.001
40287 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40288 PNM	N.D.	N.D.	N.D.	N.D.	0.008	0.005
40289 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40290 PNM*	N.D.	0.012	N.D.	N.D.	0.005	N.D.
40291 PNM*	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40295 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40296 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40297 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40300 PNM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40301 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40302 PNM*	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40303 PNM•	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40305 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40306 PNM*•	N.D.	N.D.	N.D.	N.D.	0.007	0.002
40311 PNM	0.013	N.D.	N.D.	0.14	0.005	0.084
40312 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40313 PNM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40315 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40316 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40317 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40318 PNM	N.D.	N.D.	N.D.	0.028	N.D.	0.026
40319 PNM	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40320 PNM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40321 PNM*	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40322 PNM*	N.D.	N.D.	N.D.	0.015	0.011	0.017
40323 PNM	N.D.	N.D.	N.D.	0.010	N.D.	N.D.
40324 PNM*	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40325 PNM	N.D.	N.D.	N.D.	0.009	0.012	N.D.
40326 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.005
40327 PNM*	N.D.	0.009	N.D.	N.D.	N.D.	N.D.
40328 PNM	N.D.	N.D.	N.D.	N.D.	0.016	N.D.
40329 PNM*	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40330 PNM	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40331 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	0.002
40332 PNM	N.D.	N.D.	N.D.	N.D.	0.008	0.019
40333 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40334 PNM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40335 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40336 PNM	N.D.	0.012	N.D.	N.D.	0.008	N.D.
40338 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40342 PNM	N.D.	N.D.	N.D.	0.026	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40343 PNM	N.D.	N.D.	N.D.	N.D.	0.008	0.003
40344 PNM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40345 PNM	N.D.	N.D.	N.D.	0.001	0.004	N.D.
40346 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40347 PNM	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40349 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40350 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40352 PNM	N.D.	N.D.	N.D.	N.D.	0.003	0.002
40353 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40354 PNM	N.D.	N.D.	N.D.	N.D.	0.023	N.D.
40357 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40358 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40359 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40360 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40361 PNM	N.D.	0.004	N.D.	0.001	0.003	0.001
40362 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40364 PNM	N.D.	0.004	N.D.	N.D.	0.001	N.D.
40365 PNM	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40366 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40369 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40371 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40372 PNM	N.D.	N.D.	N.D.	0.024	N.D.	N.D.
40375 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40376 PNM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40378 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40379 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40381 PNM	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40382 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40384 PNM*	N.D.	N.D.	N.D.	N.D.	0.010	N.D.
40386 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40388 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40390 PNM	N.D.	N.D.	N.D.	0.053	N.D.	N.D.
40392 PNM•	N.D.	N.D.	N.D.	0.019	N.D.	N.D.
40393 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40395 PNM	N.D.	0.004	N.D.	N.D.	N.D.	N.D.
40396 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40397 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40399 PNM	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40401 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40405 PNM*	N.D.	0.009	N.D.	N.D.	0.008	0.002
40406 PNM	N.D.	0.004	N.D.	N.D.	N.D.	N.D.
40409 PNM	N.D.	N.D.	N.D.	N.D.	0.023	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40411 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40412 PNM*	N.D.	0.010	N.D.	N.D.	0.009	N.D.
40413 PNM	N.D.	0.005	N.D.	0.042	N.D.	N.D.
40415 PNM•	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40416 PNM	N.D.	0.003	N.D.	N.D.	N.D.	N.D.
40417 PNM	N.D.	0.007	N.D.	0.006	N.D.	N.D.
40418 PNM	N.D.	N.D.	N.D.	0.005	N.D.	N.D.
40419 PNM	N.D.	N.D.	N.D.	0.004	0.004	N.D.
40420 PNM	N.D.	0.005	N.D.	N.D.	N.D.	N.D.
40421 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40422 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40424 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40425 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40428 PNM*	N.D.	N.D.	N.D.	N.D.	0.008	0.001
40429 PNM*	N.D.	N.D.	N.D.	N.D.	0.014	N.D.
40430 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40432 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40433 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40434 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40436 PNM	N.D.	N.D.	N.D.	0.003	N.D.	N.D.
40438 PNM	N.D.	N.D.	N.D.	N.D.	0.009	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40439 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40440 PNM	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40441 PNM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40442 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40443 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40444 PNM	N.D.	N.D.	N.D.	N.D.	0.014	N.D.
40445 PNM*	N.D.	0.019	N.D.	N.D.	0.003	N.D.
40446 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40447 PNM*•	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40449 PNM*	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40451 PNM*•	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40453 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40454 PNM*•	N.D.	0.010	N.D.	N.D.	N.D.	N.D.
40455 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40456 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	0.006
40457 PNM	0.007	N.D.	N.D.	N.D.	N.D.	N.D.
40458 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40460 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40461 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40462 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40463 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40464 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40465 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40466 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40467 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40468 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40469 PNM*	N.D.	N.D.	N.D.	0.002	N.D.	N.D.
40470 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40471 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40472 PNM	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40474 PNM*	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40475 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40476 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40478 PNM*•	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40480 PNM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40481 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40482 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40483 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40485 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40489 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40490 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40491 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40492 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40494 PNM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40495 PNM	0.019	N.D.	N.D.	N.D.	N.D.	N.D.
40496 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40497 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40498 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40499 PNM*	N.D.	N.D.	N.D.	0.018	N.D.	0.001
40500 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40504 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40505 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40506 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40507 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40508 PNM	N.D.	N.D.	N.D.	0.17	N.D.	0.053
40514 PNM*	0.021	N.D.	N.D.	N.D.	0.009	0.002
40517 PNM	N.D.	N.D.	N.D.	0.022	N.D.	N.D.
40518 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40521 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40522 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40523 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40525 PNM*	N.D.	N.D.	N.D.	0.004	N.D.	0.013
40526 PNM	N.D.	N.D.	N.D.	N.D.	0.005	0.007

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40527 PNM	N.D.	N.D.	N.D.	N.D.	0.009	N.D.
40528 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40529 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40530 PNM*	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40532 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40533 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40535 PNM	N.D.	0.020	N.D.	N.D.	N.D.	N.D.
40537 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40538 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40539 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40541 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40542 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40543 PNM*	N.D.	0.009	N.D.	N.D.	N.D.	0.002
40544 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40545 PNM	N.D.	0.005	N.D.	N.D.	N.D.	N.D.
40547 PNM*	N.D.	N.D.	N.D.	0.020	0.023	0.020
40548 PNM*	0.029	N.D.	N.D.	N.D.	0.002	0.004
40549 PNM	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40551 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40552 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40554 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40556 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40557 PNM•	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40558 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40559 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40560 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40561 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40563 PNM	N.D.	0.003	N.D.	N.D.	N.D.	N.D.
40564 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40566 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40568 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40571 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40573 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40575 PNM	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40576 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40579 PNM*•	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40580 PNM•	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40583 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40584 PNM	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40586 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40587 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.002
40588 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40589 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40590 PNM	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40592 PNM	N.D.	N.D.	N.D.	0.071	N.D.	0.002
40593 PNM	N.D.	0.002	N.D.	N.D.	N.D.	0.005
40594 PNM*	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40600 PNM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40602 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40603 PNM	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40604 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40605 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40607 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40611 PNM*•	N.D.	0.009	N.D.	N.D.	0.001	N.D.
40612 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	0.006
40613 PNM	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40614 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.003
40616 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40620 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40623 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40625 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40628 PNM	N.D.	0.005	N.D.	N.D.	N.D.	N.D.
40629 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40630 PNM•	N.D.	N.D.	N.D.	0.092	N.D.	0.034
40631 PNM	N.D.	0.004	N.D.	N.D.	N.D.	N.D.
40632 PNM	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40633 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40644 PNM	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40646 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40647 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40648 PNM	N.D.	0.003	N.D.	N.D.	N.D.	N.D.
40649 PNM	N.D.	0.003	N.D.	N.D.	N.D.	N.D.
40650 PNM	N.D.	0.003	N.D.	N.D.	0.003	N.D.
40651 PNM	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40652 PNM*•	0.008	0.009	N.D.	N.D.	N.D.	N.D.
40653 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40654 PNM	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40656 PNM•	N.D.	0.002	N.D.	N.D.	N.D.	N.D.
40659 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40661 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40662 PNM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.004
40663 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40664 PNM	0.005	0.001	N.D.	N.D.	N.D.	N.D.
40665 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40667 PNM	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40668 PNM	N.D.	0.003	N.D.	N.D.	N.D.	N.D.
40669 PNM	N.D.	0.002	N.D.	N.D.	0.003	N.D.
40670 PNM*	N.D.	0.013	N.D.	N.D.	N.D.	N.D.
40671 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40673 PNM	N.D.	N.D.	N.D.	0.014	0.005	0.029
40674 PNM	N.D.	N.D.	N.D.	N.D.	0.001	0.002
40676 PNM	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40677 PNM	0.003	N.D.	N.D.	N.D.	N.D.	N.D.
40680 PNM	0.009	N.D.	N.D.	N.D.	N.D.	N.D.
40683 PNM	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40686 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40688 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40689 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40690 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40691 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40692 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40693 PNM	N.D.	N.D.	N.D.	N.D.	0.016	N.D.
40694 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40695 PNM	N.D.	0.001	N.D.	N.D.	N.D.	N.D.
40696 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40697 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40698 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40699 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40704 PNM	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40705 PNM	N.D.	0.007	N.D.	N.D.	0.003	N.D.
40706 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40707 PNM	0.004	N.D.	N.D.	N.D.	N.D.	N.D.
40708 PNM	0.025	N.D.	N.D.	0.050	N.D.	0.011
40709 PNM	N.D.	0.004	N.D.	N.D.	N.D.	N.D.
40710 PNM•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40711 PNM	N.D.	0.015	N.D.	N.D.	0.006	N.D.
40712 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40713 PNM	N.D.	0.004	N.D.	N.D.	N.D.	N.D.
40718 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40719 PNM*•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40720 PNM	0.013	N.D.	N.D.	N.D.	N.D.	N.D.
40722 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40723 PNM	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40724 PNM	N.D.	N.D.	N.D.	N.D.	0.001	0.004
40725 PNM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40726 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40727 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40730 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40731 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40732 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40739 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40740 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40745 PNM	N.D.	N.D.	N.D.	0.025	0.007	0.006
40792 PNM	0.008	N.D.	N.D.	N.D.	N.D.	0.006
40834 PNM	N.D.	0.010	N.D.	N.D.	N.D.	N.D.
40890 PNM	0.006	N.D.	N.D.	N.D.	0.001	0.003
40891 PNM	N.D.	0.007	N.D.	N.D.	N.D.	N.D.
40893 PNM	N.D.	0.008	N.D.	N.D.	N.D.	N.D.
40894 PNM	N.D.	0.008	N.D.	N.D.	0.001	N.D.
40925 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	0.003
40931 PNM	0.006	N.D.	N.D.	N.D.	N.D.	N.D.
40955 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
41077 PNM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Appendix C: Concentrations of PFCAs and PFSAs in maternal plasma one year after delivery (ng/mL).

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40004 1YRM	0.57	N.D.	N.D.	0.36	0.26	0.14	0.13	N.D.	0.34	1.3	N.D.
40013 1YRM	1.6	N.D.	N.D.	1.0	0.42	0.17	0.064	N.D.	1.4	3.3	N.D.
40014 1YRM	0.66	N.D.	0.050	0.96	0.27	0.13	0.10	N.D.	0.95	2.8	N.D.
40016 1YRM	0.65	N.D.	0.060	0.79	0.54	0.23	0.16	N.D.	0.19	1.8	N.D.
40024 1YRM	0.50	N.D.	N.D.	0.54	0.31	0.14	0.10	N.D.	0.32	2.6	N.D.
40025 1YRM	0.59	N.D.	N.D.	0.40	0.28	0.10	0.084	N.D.	0.73	1.8	N.D.
40027 1YRM	0.33	N.D.	N.D.	0.67	0.44	0.12	N.D.	N.D.	0.30	3.1	N.D.
40028 1YRM	1.1	N.D.	N.D.	0.61	0.25	0.12	N.D.	N.D.	0.70	2.5	N.D.
40030 1YRM	0.75	N.D.	N.D.	1.0	0.26	N.D.	0.037	N.D.	0.72	1.5	N.D.
40032 1YRM	0.58	N.D.	N.D.	1.1	2.3	1.3	1.0	N.D.	0.64	20	0.16
40033 1YRM	0.88	N.D.	N.D.	0.22	0.20	0.10	0.094	N.D.	0.21	1.1	N.D.
40036 1YRM	0.54	N.D.	N.D.	1.1	0.38	0.17	N.D.	N.D.	1.3	4.2	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40040 1YRM	0.69	0.12	0.14	1.4	0.57	0.31	0.18	N.D.	16	4.1	N.D.
40043 1YRM	0.79	N.D.	0.15	0.49	0.71	0.39	0.65	N.D.	0.35	5.1	N.D.
40047 1YRM	1.0	N.D.	N.D.	0.70	0.31	0.13	N.D.	N.D.	0.33	2.6	N.D.
40048 1YRM	0.67	N.D.	0.15	0.33	0.38	0.11	0.058	N.D.	0.41	1.8	N.D.
40051 1YRM	0.51	0.055	0.024	0.74	0.34	0.12	0.10	N.D.	0.39	1.8	N.D.
40052 1YRM	0.40	N.D.	N.D.	1.2	0.58	0.16	0.11	N.D.	0.73	2.0	N.D.
40054 1YRM	1.8	N.D.	N.D.	0.59	0.41	0.15	0.063	N.D.	0.45	1.4	N.D.
40057 1YRM	1.0	N.D.	0.14	1.4	0.33	N.D.	0.058	N.D.	1.9	2.5	N.D.
40060 1YRM	1.1	N.D.	0.055	0.45	0.39	0.22	0.060	N.D.	0.19	1.4	N.D.
40062 1YRM	0.55	N.D.	N.D.	1.1	0.65	0.31	0.24	N.D.	0.70	3.0	N.D.
40064 1YRM	0.57	N.D.	0.096	1.2	0.41	0.21	0.13	N.D.	0.73	3.0	N.D.
40065 1YRM	1.0	N.D.	N.D.	0.27	0.28	0.11	0.099	N.D.	0.22	1.9	N.D.
40066 1YRM	0.92	N.D.	N.D.	0.64	0.30	N.D.	0.071	N.D.	1.3	2.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40067 1YRM	0.79	N.D.	0.19	0.70	0.28	N.D.	0.046	N.D.	0.50	1.9	N.D.
40069 1YRM	1.2	N.D.	0.052	0.24	0.18	N.D.	0.046	N.D.	N.D.	0.30	N.D.
40071 1YRM	0.77	N.D.	N.D.	0.38	0.39	0.19	0.16	N.D.	0.32	1.6	N.D.
40074 1YRM*	1.1	0.030	N.D.	0.20	0.32	0.19	0.12	N.D.	0.12	2.4	N.D.
40076 1YRM	0.70	N.D.	0.090	2.7	0.39	0.19	0.14	N.D.	0.54	2.2	N.D.
40077 1YRM	0.26	N.D.	N.D.	0.67	0.28	0.12	0.16	N.D.	0.41	1.5	N.D.
40078 1YRM	0.25	N.D.	0.12	0.43	0.33	0.15	0.11	N.D.	0.49	3.2	N.D.
40081 1YRM	0.53	N.D.	0.11	1.2	0.62	0.21	0.096	N.D.	0.30	5.2	N.D.
40082 1YRM	0.58	N.D.	0.048	0.42	0.39	0.12	0.069	N.D.	0.18	1.7	N.D.
40083 1YRM	1.0	N.D.	0.096	0.41	0.21	0.091	0.064	N.D.	0.96	1.1	N.D.
40085 1YRM	0.61	N.D.	0.091	0.78	0.36	0.17	0.093	N.D.	0.63	4.3	N.D.
40086 1YRM	0.40	N.D.	N.D.	0.37	0.30	0.14	0.071	N.D.	0.11	1.2	N.D.
40087 1YRM	0.43	N.D.	N.D.	0.20	0.15	N.D.	N.D.	N.D.	0.31	0.60	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40089 1YRM	0.47	N.D.	0.097	0.38	N.D.	N.D.	N.D.	N.D.	0.20	1.3	N.D.
40090 1YRM	0.25	N.D.	N.D.	1.1	0.31	0.10	0.093	N.D.	3.3	2.7	N.D.
40092 1YRM	0.67	N.D.	0.021	1.1	0.46	0.19	0.075	N.D.	0.98	3.4	0.080
40094 1YRM	N.D.	N.D.	N.D.	0.33	0.20	0.12	0.055	N.D.	0.68	1.5	N.D.
40095 1YRM	0.24	N.D.	N.D.	0.81	N.D.	0.14	0.16	N.D.	0.39	4.6	N.D.
40097 1YRM	0.75	N.D.	N.D.	0.64	0.46	0.19	0.26	N.D.	0.73	2.4	N.D.
40098 1YRM	0.62	N.D.	N.D.	0.30	0.15	0.054	N.D.	N.D.	N.D.	0.43	N.D.
40099 1YRM	0.73	N.D.	N.D.	1.0	0.33	N.D.	0.10	N.D.	0.29	3.1	N.D.
40100 1YRM	0.96	N.D.	N.D.	0.30	0.24	0.090	0.073	N.D.	0.17	0.91	N.D.
40101 1YRM	0.40	N.D.	0.024	0.42	0.24	0.093	0.044	N.D.	N.D.	1.1	N.D.
40102 1YRM	0.71	N.D.	N.D.	0.48	N.D.	N.D.	N.D.	N.D.	0.23	1.5	N.D.
40103 1YRM	0.43	N.D.	0.055	2.6	1.0	0.49	0.16	N.D.	2.8	6.1	N.D.
40104 1YRM	0.43	N.D.	0.056	0.71	0.38	0.17	0.20	N.D.	0.39	1.8	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40105 1YRM	1.1	N.D.	N.D.	2.0	0.49	N.D.	0.065	N.D.	0.65	10	0.19
40106 1YRM	0.77	N.D.	N.D.	1.4	0.36	N.D.	0.048	N.D.	1.5	2.4	0.043
40107 1YRM	1.0	N.D.	N.D.	0.27	N.D.	0.13	N.D.	N.D.	0.38	2.1	N.D.
40110 1YRM*	0.78	N.D.	N.D.	0.31	0.39	0.18	0.26	N.D.	0.37	3.2	N.D.
40111 1YRM	1.0	N.D.	0.002	0.44	0.21	0.055	0.038	N.D.	0.20	0.95	N.D.
40114 1YRM	0.56	N.D.	N.D.	0.25	0.35	0.10	0.065	N.D.	0.25	1.3	N.D.
40115 1YRM	0.56	N.D.	0.047	0.56	0.32	0.15	0.061	N.D.	1.5	2.5	N.D.
40116 1YRM	0.72	N.D.	0.014	1.3	0.65	0.17	0.050	N.D.	0.40	2.9	N.D.
40117 1YRM	0.40	0.035	0.070	0.51	0.29	0.13	N.D.	N.D.	0.22	1.6	N.D.
40118 1YRM	0.76	N.D.	N.D.	0.51	0.22	0.10	0.058	N.D.	0.17	0.76	N.D.
40120 1YRM	0.67	N.D.	N.D.	0.45	0.26	N.D.	N.D.	N.D.	0.32	1.4	N.D.
40123 1YRM	1.4	N.D.	N.D.	0.88	0.41	0.16	0.085	N.D.	0.27	2.0	N.D.
40124 1YRM*	0.57	N.D.	N.D.	0.23	0.32	0.19	0.24	N.D.	0.15	2.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40126 1YRM	1.5	N.D.	N.D.	0.17	0.21	N.D.	0.075	N.D.	0.12	1.1	N.D.
40128 1YRM	0.55	N.D.	N.D.	0.53	N.D.	N.D.	N.D.	N.D.	0.67	1.3	N.D.
40129 1YRM	0.92	N.D.	0.004	0.53	0.31	0.12	0.056	N.D.	0.71	2.1	N.D.
40132 1YRM	1.6	N.D.	N.D.	0.27	0.29	0.087	0.058	N.D.	0.24	1.5	N.D.
40134 1YRM*	0.37	N.D.	0.039	0.28	0.63	0.40	0.38	N.D.	0.30	7.9	0.086
40135 1YRM	0.74	N.D.	N.D.	0.57	0.49	0.13	0.069	N.D.	0.47	5.0	N.D.
40136 1YRM	0.48	N.D.	N.D.	1.7	0.41	0.12	0.078	N.D.	4.3	3.1	N.D.
40137 1YRM	0.86	0.063	N.D.	0.21	0.21	N.D.	0.033	N.D.	0.17	0.79	N.D.
40138 1YRM*	1.2	N.D.	0.015	0.36	0.21	0.10	0.045	N.D.	0.22	1.5	N.D.
40139 1YRM*	0.64	N.D.	N.D.	0.31	0.30	0.16	N.D.	N.D.	0.29	2.0	N.D.
40140 1YRM*	0.99	N.D.	N.D.	0.39	0.42	0.17	0.15	N.D.	0.20	3.3	N.D.
40141 1YRM	1.1	N.D.	N.D.	0.94	N.D.	0.36	N.D.	N.D.	0.30	1.9	N.D.
40142 1YRM*	0.72	N.D.	N.D.	0.18	0.23	0.12	0.091	N.D.	0.49	1.7	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40143 1YRM*	0.59	N.D.	N.D.	0.55	0.41	0.16	0.14	N.D.	0.20	2.4	N.D.
40144 1YRM*	0.81	N.D.	N.D.	0.35	0.17	0.051	N.D.	N.D.	0.063	0.22	N.D.
40146 1YRM*	0.79	N.D.	0.018	1.1	0.53	0.23	0.12	N.D.	1.5	2.7	N.D.
40147 1YRM*	1.8	N.D.	N.D.	0.65	0.50	0.14	0.081	N.D.	0.46	2.3	N.D.
40148 1YRM*	0.61	N.D.	N.D.	0.46	0.35	0.16	0.16	N.D.	0.27	1.6	N.D.
40150 1YRM*	0.78	N.D.	0.038	0.51	0.34	N.D.	0.083	N.D.	0.43	1.8	N.D.
40156 1YRM*	0.94	N.D.	N.D.	0.62	0.43	0.17	0.071	N.D.	0.58	1.4	N.D.
40157 1YRM*	0.87	N.D.	N.D.	0.85	0.74	N.D.	0.094	N.D.	0.23	2.4	N.D.
40158 1YRM*	0.60	N.D.	0.24	2.3	0.87	0.46	0.20	N.D.	2.2	1.2	N.D.
40159 1YRM*	1.1	N.D.	N.D.	0.38	0.34	0.13	0.12	N.D.	0.31	2.5	N.D.
40161 1YRM*	1.1	N.D.	0.095	0.67	0.36	0.13	0.076	N.D.	0.35	1.6	N.D.
40162 1YRM*	0.62	N.D.	N.D.	0.80	0.40	0.15	0.061	N.D.	0.40	3.6	N.D.
40164 1YRM*	0.54	N.D.	N.D.	0.86	0.39	0.14	0.066	N.D.	0.30	2.6	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40166 1YRM*	0.63	N.D.	N.D.	0.91	N.D.	0.11	N.D.	N.D.	2.6	2.3	N.D.
40169 1YRM*	0.76	N.D.	0.024	0.34	0.22	0.13	0.13	N.D.	0.21	1.7	0.058
40170 1YRM*	1.1	N.D.	N.D.	0.49	0.25	0.11	0.053	N.D.	0.40	1.6	N.D.
40172 1YRM*	0.50	N.D.	N.D.	0.30	0.18	0.10	N.D.	N.D.	0.52	1.1	N.D.
40174 1YRM	0.42	N.D.	0.20	1.8	0.85	0.24	N.D.	N.D.	0.55	1.4	N.D.
40175 1YRM*	2.4	N.D.	0.066	0.35	0.22	0.042	0.059	N.D.	0.19	0.40	N.D.
40176 1YRM*	1.1	N.D.	0.029	0.20	0.16	0.077	0.067	N.D.	0.17	0.78	N.D.
40177 1YRM*	0.33	N.D.	N.D.	0.40	0.75	0.27	0.21	N.D.	0.19	5.3	N.D.
40178 1YRM*	0.87	0.008	0.018	1.1	0.43	0.14	0.063	N.D.	3.1	2.6	N.D.
40179 1YRM*	0.66	N.D.	0.043	0.83	0.32	0.11	0.057	N.D.	0.29	3.6	0.045
40180 1YRM*	0.61	N.D.	N.D.	1.1	0.39	0.12	0.078	N.D.	0.56	1.6	N.D.
40183 1YRM	0.31	N.D.	N.D.	0.21	N.D.	0.078	0.057	N.D.	N.D.	0.72	N.D.
40184 1YRM	0.32	N.D.	N.D.	0.64	0.85	0.27	0.12	N.D.	0.54	6.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40185 1YRM*	0.91	N.D.	0.042	0.35	0.19	0.090	0.090	N.D.	1.3	1.6	N.D.
40186 1YRM*	0.51	N.D.	N.D.	0.28	0.34	0.12	N.D.	N.D.	0.39	1.6	N.D.
40187 1YRM*	0.39	N.D.	N.D.	0.60	0.32	N.D.	0.071	N.D.	1.4	1.8	N.D.
40188 1YRM*	0.64	N.D.	0.009	0.72	0.34	0.10	0.042	N.D.	1.7	1.2	0.054
40189 1YRM	0.63	N.D.	N.D.	0.18	0.19	N.D.	N.D.	N.D.	0.12	0.77	N.D.
40190 1YRM*	0.75	0.042	N.D.	0.53	0.29	0.14	0.11	N.D.	0.58	1.9	N.D.
40192 1YRM*	0.48	N.D.	N.D.	1.0	0.61	0.15	0.090	N.D.	0.26	3.5	N.D.
40193 1YRM*	1.5	N.D.	0.060	0.71	N.D.	0.11	N.D.	N.D.	0.29	1.0	N.D.
40194 1YRM*	0.68	0.070	N.D.	1.7	0.61	0.23	0.26	N.D.	0.55	3.5	N.D.
40195 1YRM*	0.84	N.D.	N.D.	0.21	N.D.	0.075	0.044	N.D.	0.061	0.53	N.D.
40196 1YRM*	1.0	0.005	N.D.	0.28	0.20	0.094	0.065	N.D.	0.15	0.79	N.D.
40197 1YRM*	0.39	N.D.	N.D.	0.56	0.65	0.19	0.18	N.D.	0.77	2.7	0.037
40198 1YRM*	0.93	N.D.	N.D.	0.48	0.48	0.17	0.16	N.D.	0.45	1.6	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40203 1YRM*	0.73	N.D.	N.D.	0.81	0.38	0.16	N.D.	N.D.	0.57	3.6	N.D.
40205 1YRM*	0.76	N.D.	N.D.	0.51	0.35	0.15	N.D.	N.D.	0.50	1.7	N.D.
40206 1YRM*	0.96	N.D.	N.D.	0.63	0.37	N.D.	0.22	N.D.	1.4	2.8	N.D.
40207 1YRM	0.78	N.D.	N.D.	0.60	0.33	0.16	N.D.	N.D.	0.41	1.5	N.D.
40209 1YRM*	0.91	N.D.	0.019	0.57	0.35	0.13	0.083	N.D.	0.64	1.8	0.056
40211 1YRM*	1.9	N.D.	0.051	0.45	N.D.	0.14	0.099	N.D.	0.18	0.93	N.D.
40216 1YRM	0.51	N.D.	0.045	0.64	0.30	0.17	0.13	N.D.	0.28	1.7	N.D.
40218 1YRM*	0.59	N.D.	0.022	0.55	N.D.	0.12	0.065	N.D.	0.36	1.8	0.036
40225 1YRM*	0.69	N.D.	N.D.	1.2	0.30	0.096	N.D.	N.D.	0.42	1.1	0.059
40232 1YRM*	1.0	N.D.	N.D.	0.44	0.20	0.080	N.D.	N.D.	0.39	1.1	N.D.
40235 1YRM*	1.4	N.D.	N.D.	0.55	0.28	0.12	0.086	N.D.	1.5	2.7	N.D.
40239 1YRM	0.46	0.017	N.D.	0.80	0.52	0.29	0.16	N.D.	2.6	2.3	N.D.
40240 1YRM	0.44	N.D.	N.D.	0.37	0.23	0.098	N.D.	N.D.	0.55	1.2	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40243 1YRM*	1.2	N.D.	N.D.	0.36	0.21	0.10	0.065	N.D.	0.25	1.9	N.D.
40244 1YRM*	1.3	N.D.	0.066	1.1	0.41	0.16	0.083	N.D.	1.4	2.9	N.D.
40245 1YRM*	0.29	N.D.	N.D.	0.54	0.72	0.16	0.18	N.D.	0.53	2.8	N.D.
40246 1YRM*	0.32	N.D.	0.073	0.27	0.49	0.25	0.19	N.D.	0.16	3.4	0.093
40247 1YRM*	1.1	N.D.	N.D.	0.35	0.24	0.10	0.055	N.D.	0.26	1.9	N.D.
40250 1YRM*	1.0	0.23	0.049	0.27	0.16	0.071	N.D.	0.071	0.19	1.0	N.D.
40252 1YRM*	0.86	N.D.	0.052	0.30	0.21	0.092	0.061	N.D.	0.088	0.79	N.D.
40254 1YRM*	1.1	N.D.	N.D.	0.25	N.D.	0.11	N.D.	N.D.	0.24	2.3	0.040
40255 1YRM*	0.87	N.D.	N.D.	0.51	0.37	0.13	0.081	N.D.	0.30	2.7	N.D.
40256 1YRM*	1.4	N.D.	N.D.	0.38	0.33	0.11	0.078	N.D.	0.49	1.6	N.D.
40257 1YRM*	0.83	N.D.	N.D.	0.65	0.32	0.23	0.057	N.D.	0.33	1.9	N.D.
40258 1YRM*	0.34	N.D.	0.073	0.58	0.34	0.19	0.19	N.D.	0.19	1.9	0.055
40259 1YRM*	0.91	N.D.	0.049	0.95	0.38	N.D.	0.043	N.D.	0.34	2.3	0.065

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40261 1YRM*	0.61	N.D.	N.D.	0.32	N.D.	0.077	N.D.	N.D.	0.14	0.81	N.D.
40264 1YRM*	0.89	N.D.	0.045	0.45	1.7	0.77	0.77	N.D.	0.42	9.5	0.13
40265 1YRM*	1.1	N.D.	N.D.	1.4	0.62	0.29	0.14	N.D.	0.41	1.8	N.D.
40266 1YRM	0.41	N.D.	N.D.	1.0	0.33	N.D.	0.084	N.D.	3.4	3.4	N.D.
40268 1YRM*	1.0	N.D.	N.D.	0.41	0.27	0.096	0.044	N.D.	0.89	1.6	N.D.
40269 1YRM*	0.39	N.D.	N.D.	1.2	0.26	0.097	0.058	N.D.	4.6	3.8	N.D.
40271 1YRM*	0.56	N.D.	0.076	0.21	0.12	N.D.	N.D.	N.D.	0.13	0.44	N.D.
40272 1YRM*	0.91	0.043	0.083	0.93	0.28	0.11	0.037	N.D.	0.55	1.1	N.D.
40273 1YRM*	0.88	N.D.	N.D.	0.65	0.64	0.37	0.24	N.D.	0.15	1.8	N.D.
40274 1YRM*	0.96	0.012	N.D.	0.30	0.40	0.078	0.088	N.D.	0.42	1.3	N.D.
40276 1YRM*	0.95	N.D.	N.D.	0.17	0.21	0.097	0.10	N.D.	0.26	1.1	N.D.
40277 1YRM	0.62	N.D.	N.D.	0.21	N.D.	0.096	0.092	N.D.	0.14	0.82	N.D.
40279 1YRM*	0.71	N.D.	N.D.	0.59	0.30	0.12	0.093	N.D.	0.79	2.0	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40280 1YRM*	1.3	N.D.	0.066	0.19	0.15	0.082	0.040	N.D.	0.66	0.69	N.D.
40283 1YRM	1.6	N.D.	0.044	0.81	N.D.	N.D.	0.086	N.D.	0.68	2.4	0.046
40284 1YRM*	1.3	N.D.	N.D.	0.34	0.28	0.15	0.080	N.D.	0.17	1.1	N.D.
40289 1YRM*	0.54	N.D.	N.D.	0.96	0.45	0.17	0.058	N.D.	0.31	4.0	N.D.
40290 1YRM*	0.47	N.D.	N.D.	1.2	0.38	0.14	0.057	N.D.	0.42	3.2	N.D.
40291 1YRM*	1.1	N.D.	0.066	0.31	0.31	N.D.	0.046	N.D.	1.8	1.0	N.D.
40295 1YRM*	0.89	N.D.	0.050	0.46	0.27	0.13	0.057	N.D.	0.14	1.2	N.D.
40297 1YRM*	1.2	N.D.	N.D.	0.45	0.46	0.14	0.11	N.D.	0.30	2.0	N.D.
40301 1YRM*	1.5	N.D.	N.D.	1.0	0.39	0.11	0.063	N.D.	1.4	2.2	N.D.
40302 1YRM*	0.90	N.D.	N.D.	0.48	0.33	0.15	0.14	N.D.	0.53	1.7	N.D.
40304 1YRM	0.45	N.D.	N.D.	0.47	0.38	N.D.	0.11	N.D.	0.55	2.7	N.D.
40306 1YRM*	0.77	N.D.	N.D.	0.15	0.19	0.22	N.D.	N.D.	0.18	2.6	N.D.
40312 1YRM*	1.7	N.D.	0.051	0.39	0.29	0.10	0.077	N.D.	0.27	0.91	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40313 1YRM*	1.2	N.D.	N.D.	0.47	0.45	N.D.	0.056	N.D.	0.20	1.4	N.D.
40316 1YRM*	2.0	N.D.	N.D.	0.61	0.40	0.21	0.33	N.D.	0.78	2.5	N.D.
40320 1YRM*	1.2	N.D.	N.D.	1.6	0.51	0.27	0.34	N.D.	0.23	2.4	N.D.
40321 1YRM*	1.3	N.D.	N.D.	0.21	0.29	N.D.	0.083	N.D.	0.22	5.1	N.D.
40322 1YRM*	0.44	0.054	0.055	0.57	0.37	0.13	0.047	N.D.	0.51	1.7	N.D.
40324 1YRM*	1.1	N.D.	N.D.	1.3	0.51	0.14	0.046	N.D.	0.63	2.9	N.D.
40326 1YRM*	1.7	N.D.	N.D.	0.68	0.38	N.D.	0.074	N.D.	0.37	1.8	N.D.
40327 1YRM*	0.54	N.D.	N.D.	0.86	0.35	0.079	0.060	N.D.	0.93	1.6	N.D.
40329 1YRM*	1.7	N.D.	N.D.	0.58	0.33	N.D.	N.D.	N.D.	0.31	1.2	N.D.
40334 1YRM*	0.91	N.D.	N.D.	0.69	N.D.	0.095	0.059	N.D.	0.85	1.7	N.D.
40344 1YRM*	1.0	N.D.	N.D.	0.78	0.31	0.091	0.042	N.D.	0.48	1.1	N.D.
40370 1YRM	0.45	N.D.	N.D.	0.61	0.24	N.D.	0.057	N.D.	0.29	2.2	N.D.
40382 1YRM*	0.80	N.D.	N.D.	0.42	0.24	0.14	0.11	N.D.	0.85	2.5	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40384 1YRM*	1.1	N.D.	N.D.	0.64	0.45	0.22	0.15	N.D.	0.43	2.2	N.D.
40405 1YRM*	1.7	N.D.	N.D.	0.36	0.24	N.D.	0.063	N.D.	0.43	1.0	N.D.
40411 1YRM*	0.62	N.D.	0.050	0.37	0.28	0.076	0.038	N.D.	0.57	1.7	N.D.
40412 1YRM*	1.4	N.D.	N.D.	0.38	0.27	0.099	0.048	N.D.	0.29	1.2	0.054
40428 1YRM*	0.98	N.D.	N.D.	0.64	0.34	0.13	0.090	N.D.	0.42	1.8	N.D.
40429 1YRM*	1.5	N.D.	0.046	2.0	0.50	N.D.	N.D.	N.D.	0.95	2.9	0.039
40441 1YRM*	0.72	N.D.	N.D.	0.71	0.31	0.060	N.D.	N.D.	0.29	0.64	N.D.
40445 1YRM*	0.62	N.D.	0.076	1.4	0.52	0.15	0.054	N.D.	0.48	1.3	0.034
40447 1YRM*	2.1	N.D.	N.D.	0.30	0.24	0.11	N.D.	N.D.	0.57	2.5	N.D.
40449 1YRM*	0.60	N.D.	N.D.	0.68	0.28	0.11	0.097	N.D.	0.84	2.4	N.D.
40451 1YRM*	1.4	N.D.	N.D.	0.28	0.28	N.D.	0.067	N.D.	0.23	0.80	N.D.
40454 1YRM*	1.7	N.D.	0.10	0.99	0.34	0.21	0.071	N.D.	0.40	1.3	N.D.
40456 1YRM*	0.64	N.D.	0.12	0.93	0.39	0.11	0.059	N.D.	1.0	1.1	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40458 1YRM*	0.54	N.D.	N.D.	0.64	0.44	0.12	N.D.	N.D.	0.40	1.4	N.D.
40459 1YRM	1.1	0.039	N.D.	0.81	0.42	0.13	0.057	N.D.	1.2	2.9	N.D.
40460 1YRM*	0.54	N.D.	N.D.	0.32	0.55	0.24	0.22	N.D.	0.24	2.5	N.D.
40461 1YRM*	0.51	0.14	0.088	1.2	0.29	0.12	0.042	N.D.	0.23	1.1	N.D.
40464 1YRM*	1.1	N.D.	N.D.	0.20	0.25	0.14	0.12	N.D.	0.21	1.6	N.D.
40465 1YRM*	1.8	N.D.	N.D.	0.76	0.39	0.14	0.080	N.D.	1.4	2.7	N.D.
40466 1YRM*	1.4	0.12	0.045	0.32	0.23	N.D.	N.D.	N.D.	0.43	1.9	N.D.
40467 1YRM*	1.5	N.D.	N.D.	0.29	0.29	0.13	0.096	N.D.	0.49	2.9	N.D.
40469 1YRM*	0.82	0.12	N.D.	0.30	0.32	0.096	0.040	N.D.	0.17	1.4	N.D.
40470 1YRM*	0.77	N.D.	N.D.	0.31	0.17	N.D.	N.D.	N.D.	0.25	0.71	N.D.
40474 1YRM*	0.64	N.D.	N.D.	0.67	0.79	N.D.	0.11	N.D.	0.37	1.6	N.D.
40478 1YRM*	0.87	0.15	0.070	0.32	0.37	N.D.	0.091	N.D.	0.57	1.1	N.D.
40480 1YRM*	1.7	N.D.	0.053	0.90	0.53	0.21	0.099	N.D.	0.49	2.6	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40485 1YRM*	2.2	N.D.	N.D.	0.74	0.33	0.093	N.D.	N.D.	2.0	1.2	N.D.
40490 1YRM*	0.38	N.D.	0.057	0.78	N.D.	0.11	N.D.	N.D.	0.27	1.2	N.D.
40491 1YRM*	1.1	N.D.	N.D.	0.49	0.38	N.D.	0.10	N.D.	0.55	1.8	N.D.
40492 1YRM*	1.4	N.D.	N.D.	0.34	0.24	N.D.	N.D.	N.D.	0.28	1.6	N.D.
40499 1YRM*	0.75	N.D.	N.D.	0.48	0.53	0.27	0.27	N.D.	0.92	2.3	N.D.
40500 1YRM*	1.1	N.D.	0.043	0.35	0.30	0.11	0.068	N.D.	1.3	2.5	N.D.
40502 1YRM	0.66	N.D.	N.D.	0.33	0.29	0.15	0.092	N.D.	0.55	2.2	N.D.
40509 1YRM	0.67	N.D.	0.060	0.61	0.31	0.12	0.052	N.D.	0.26	1.3	N.D.
40514 1YRM*	1.1	N.D.	0.14	1.5	0.56	0.16	0.060	N.D.	2.6	1.5	N.D.
40523 1YRM*	1.6	N.D.	0.052	0.63	0.37	0.16	0.12	N.D.	0.39	3.1	N.D.
40525 1YRM*	0.72	N.D.	0.013	0.25	0.13	0.098	N.D.	N.D.	0.38	0.98	N.D.
40530 1YRM*	1.5	N.D.	N.D.	0.50	N.D.	0.099	0.087	N.D.	0.17	0.63	N.D.
40532 1YRM*	2.0	0.11	N.D.	0.40	0.24	0.10	0.040	N.D.	0.32	1.1	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40541 1YRM*	0.87	0.16	N.D.	0.32	N.D.	0.12	0.053	N.D.	0.47	1.8	N.D.
40543 1YRM*	2.3	N.D.	N.D.	0.88	0.33	N.D.	0.093	N.D.	0.54	2.1	N.D.
40544 1YRM*	1.2	0.19	N.D.	0.48	0.28	0.10	0.085	N.D.	0.32	1.8	N.D.
40547 1YRM*	1.5	N.D.	N.D.	0.53	N.D.	0.11	0.055	N.D.	2.8	2.6	N.D.
40548 1YRM*	2.3	0.10	N.D.	2.3	0.66	0.27	N.D.	N.D.	0.15	1.4	N.D.
40551 1YRM*	0.91	0.021	N.D.	0.77	0.50	0.070	0.040	N.D.	0.50	1.6	N.D.
40552 1YRM*	0.37	N.D.	0.10	0.89	0.36	0.15	0.094	N.D.	0.42	1.2	N.D.
40564 1YRM*	1.5	0.13	0.054	1.0	0.29	N.D.	0.031	N.D.	0.47	3.0	N.D.
40568 1YRM*	1.2	N.D.	0.12	1.9	0.78	0.27	0.090	N.D.	0.56	4.8	N.D.
40579 1YRM*	2.5	N.D.	N.D.	0.57	0.66	N.D.	0.11	N.D.	0.45	1.5	N.D.
40581 1YRM	0.64	N.D.	N.D.	0.25	0.22	0.083	0.13	N.D.	0.25	0.78	N.D.
40586 1YRM*	0.82	N.D.	N.D.	0.33	0.54	0.18	0.13	N.D.	0.31	2.4	N.D.
40587 1YRM*	1.3	N.D.	N.D.	1.6	0.55	0.14	0.11	N.D.	0.92	3.6	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40589 1YRM*	1.1	0.12	N.D.	0.24	0.21	N.D.	0.090	N.D.	0.16	0.81	N.D.
40594 1YRM*	1.5	N.D.	0.014	0.17	0.17	0.076	0.066	N.D.	0.13	0.84	N.D.
40602 1YRM*	0.85	N.D.	0.029	0.19	0.20	0.067	0.051	N.D.	0.26	0.55	N.D.
40605 1YRM*	0.54	N.D.	N.D.	0.57	0.33	0.080	0.026	N.D.	0.19	1.2	N.D.
40607 1YRM*	1.1	N.D.	0.022	0.53	0.41	0.18	0.094	N.D.	0.81	1.7	N.D.
40611 1YRM*	0.89	N.D.	N.D.	0.94	0.35	N.D.	0.10	N.D.	2.5	2.0	N.D.
40614 1YRM*	0.97	N.D.	0.037	0.59	0.25	0.12	0.13	N.D.	0.17	0.97	N.D.
40616 1YRM*	1.1	N.D.	N.D.	0.74	0.42	0.18	0.13	N.D.	1.0	2.6	N.D.
40633 1YRM*	0.56	0.056	0.058	0.36	N.D.	0.062	0.053	N.D.	0.24	0.57	N.D.
40646 1YRM*	1.6	N.D.	0.020	0.62	0.29	0.12	0.072	N.D.	1.1	2.1	N.D.
40652 1YRM*	0.81	N.D.	N.D.	0.41	0.42	0.12	0.11	N.D.	0.64	1.4	N.D.
40662 1YRM*	0.99	N.D.	N.D.	0.75	0.33	0.13	0.11	N.D.	0.97	2.5	N.D.
40670 1YRM*	1.0	N.D.	0.059	2.8	1.0	0.43	0.16	N.D.	0.58	2.8	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40719 1YRM*	0.52	N.D.	0.016	0.24	0.35	0.10	0.13	N.D.	0.062	0.60	N.D.

Appendix D: Concentrations of 8:2 FTUCA, FOSAs and FOSEs in maternal plasma one year after delivery (ng/mL).

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40004 1YRM	N.D.	N.D.	N.D.	0.013	N.D.	N.D.
40013 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40014 1YRM	N.D.	N.D.	N.D.	N.D.	0.016	0.004
40016 1YRM	N.D.	N.D.	N.D.	0.047	N.D.	N.D.
40024 1YRM	N.D.	N.D.	N.D.	N.D.	0.015	N.D.
40025 1YRM	N.D.	0.016	N.D.	N.D.	0.013	N.D.
40027 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40028 1YRM	N.D.	N.D.	N.D.	N.D.	0.015	N.D.
40030 1YRM	N.D.	N.D.	N.D.	0.034	N.D.	0.006
40032 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40033 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40036 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40040 1YRM	N.D.	N.D.	N.D.	N.D.	0.020	0.003
40043 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40047 1YRM	N.D.	0.007	N.D.	N.D.	N.D.	N.D.
40048 1YRM	N.D.	N.D.	N.D.	N.D.	0.019	N.D.
40051 1YRM	N.D.	0.013	N.D.	0.13	0.019	0.072
40052 1YRM	0.030	N.D.	N.D.	N.D.	0.015	N.D.
40054 1YRM	0.030	N.D.	N.D.	N.D.	0.018	0.001

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40057 1YRM	0.025	N.D.	N.D.	N.D.	0.012	N.D.
40060 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40062 1YRM	N.D.	N.D.	N.D.	N.D.	0.012	N.D.
40064 1YRM	N.D.	0.014	N.D.	0.076	0.016	0.021
40065 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40066 1YRM	N.D.	N.D.	N.D.	0.030	0.008	N.D.
40067 1YRM	N.D.	0.013	N.D.	0.013	0.013	0.003
40069 1YRM	N.D.	N.D.	N.D.	N.D.	0.011	0.001
40071 1YRM	N.D.	N.D.	N.D.	0.029	0.004	N.D.
40074 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40076 1YRM	N.D.	0.013	N.D.	N.D.	0.011	N.D.
40077 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40078 1YRM	0.014	0.015	N.D.	N.D.	0.014	N.D.
40081 1YRM	N.D.	0.013	N.D.	N.D.	N.D.	N.D.
40082 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	0.005
40083 1YRM	0.035	N.D.	N.D.	N.D.	0.012	N.D.
40085 1YRM	0.019	N.D.	N.D.	N.D.	N.D.	N.D.
40086 1YRM	N.D.	0.014	N.D.	N.D.	N.D.	N.D.
40087 1YRM	N.D.	N.D.	N.D.	N.D.	0.013	0.011
40089 1YRM	N.D.	N.D.	N.D.	0.12	0.004	0.037
40090 1YRM	0.006	0.014	N.D.	N.D.	0.013	0.003

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40092 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40094 1YRM	N.D.	0.013	N.D.	N.D.	N.D.	N.D.
40095 1YRM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40097 1YRM	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40098 1YRM	N.D.	0.014	N.D.	N.D.	0.014	N.D.
40099 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40100 1YRM	N.D.	0.012	N.D.	N.D.	0.013	N.D.
40101 1YRM	N.D.	N.D.	N.D.	N.D.	0.017	N.D.
40102 1YRM	N.D.	N.D.	N.D.	N.D.	0.008	N.D.
40103 1YRM	N.D.	N.D.	N.D.	N.D.	0.016	N.D.
40104 1YRM	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40105 1YRM	N.D.	0.017	N.D.	N.D.	0.011	N.D.
40106 1YRM	N.D.	N.D.	N.D.	0.038	0.007	N.D.
40107 1YRM	N.D.	N.D.	N.D.	0.032	N.D.	N.D.
40110 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40111 1YRM	N.D.	N.D.	N.D.	N.D.	0.013	N.D.
40114 1YRM	N.D.	0.014	N.D.	N.D.	0.014	N.D.
40115 1YRM	N.D.	N.D.	N.D.	0.027	N.D.	N.D.
40116 1YRM	N.D.	N.D.	N.D.	N.D.	0.017	N.D.
40117 1YRM	0.014	N.D.	N.D.	N.D.	0.001	N.D.
40118 1YRM	N.D.	N.D.	N.D.	N.D.	0.017	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40120 1YRM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40123 1YRM	N.D.	0.014	N.D.	N.D.	N.D.	N.D.
40124 1YRM*	N.D.	N.D.	N.D.	N.D.	0.016	N.D.
40126 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40128 1YRM	N.D.	0.004	N.D.	N.D.	0.001	N.D.
40129 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40132 1YRM	N.D.	0.015	N.D.	N.D.	0.013	N.D.
40134 1YRM*	0.010	N.D.	N.D.	N.D.	N.D.	N.D.
40135 1YRM	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40136 1YRM	N.D.	0.017	N.D.	N.D.	0.014	N.D.
40137 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40138 1YRM*	N.D.	N.D.	N.D.	0.013	N.D.	N.D.
40139 1YRM*	N.D.	N.D.	N.D.	N.D.	0.015	N.D.
40140 1YRM*	0.006	N.D.	N.D.	N.D.	0.011	N.D.
40141 1YRM	N.D.	0.005	N.D.	N.D.	0.005	N.D.
40142 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40143 1YRM*	N.D.	N.D.	N.D.	N.D.	0.012	N.D.
40144 1YRM*	0.003	N.D.	N.D.	N.D.	0.016	0.001
40146 1YRM*	N.D.	N.D.	N.D.	0.011	N.D.	N.D.
40147 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40148 1YRM*	N.D.	0.010	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40150 1YRM*	N.D.	0.010	N.D.	N.D.	N.D.	0.001
40156 1YRM*	N.D.	N.D.	N.D.	N.D.	0.009	0.003
40157 1YRM*	N.D.	N.D.	N.D.	N.D.	0.013	0.004
40158 1YRM*	N.D.	N.D.	N.D.	0.017	0.010	N.D.
40159 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.003
40161 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40162 1YRM*	N.D.	N.D.	N.D.	N.D.	0.003	0.001
40164 1YRM*	N.D.	N.D.	N.D.	N.D.	0.016	0.001
40166 1YRM*	0.016	N.D.	N.D.	N.D.	N.D.	N.D.
40169 1YRM*	N.D.	N.D.	N.D.	N.D.	0.013	N.D.
40170 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40172 1YRM*	N.D.	N.D.	N.D.	0.093	N.D.	0.058
40174 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40175 1YRM*	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40176 1YRM*	N.D.	N.D.	N.D.	0.008	0.005	0.018
40177 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40178 1YRM*	N.D.	N.D.	N.D.	0.011	N.D.	0.002
40179 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40180 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40183 1YRM	N.D.	N.D.	N.D.	0.033	N.D.	N.D.
40184 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40185 1YRM*	0.011	N.D.	N.D.	N.D.	N.D.	N.D.
40186 1YRM*	N.D.	N.D.	N.D.	N.D.	0.016	N.D.
40187 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.002
40188 1YRM*	N.D.	N.D.	N.D.	0.011	0.017	N.D.
40189 1YRM	N.D.	N.D.	N.D.	0.035	0.005	N.D.
40190 1YRM*	N.D.	N.D.	N.D.	N.D.	0.003	0.006
40192 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.004
40193 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40194 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.004
40195 1YRM*	N.D.	N.D.	N.D.	N.D.	0.004	0.011
40196 1YRM*	N.D.	0.007	N.D.	0.011	0.009	N.D.
40197 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40198 1YRM*	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40203 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40205 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40206 1YRM*	0.016	N.D.	N.D.	N.D.	N.D.	N.D.
40207 1YRM	N.D.	N.D.	N.D.	0.083	N.D.	N.D.
40209 1YRM*	N.D.	N.D.	N.D.	N.D.	0.013	N.D.
40211 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40216 1YRM	N.D.	N.D.	N.D.	0.041	0.008	N.D.
40218 1YRM*	N.D.	0.010	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40225 1YRM*	N.D.	0.011	N.D.	N.D.	N.D.	N.D.
40232 1YRM*	N.D.	0.010	N.D.	N.D.	N.D.	N.D.
40235 1YRM*	N.D.	0.011	N.D.	N.D.	0.001	0.002
40239 1YRM	N.D.	N.D.	N.D.	0.010	N.D.	N.D.
40240 1YRM	N.D.	0.004	N.D.	0.033	0.001	N.D.
40243 1YRM*	N.D.	0.009	N.D.	N.D.	N.D.	N.D.
40244 1YRM*	0.005	N.D.	N.D.	N.D.	0.005	0.004
40245 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40246 1YRM*	N.D.	0.008	N.D.	N.D.	N.D.	N.D.
40247 1YRM*	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40250 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40252 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40254 1YRM*	0.012	N.D.	N.D.	N.D.	0.003	N.D.
40255 1YRM*	N.D.	0.009	N.D.	N.D.	N.D.	0.008
40256 1YRM*	N.D.	0.012	N.D.	0.001	0.001	N.D.
40257 1YRM*	0.022	N.D.	N.D.	N.D.	0.001	0.002
40258 1YRM*	N.D.	0.009	N.D.	N.D.	0.003	N.D.
40259 1YRM*	N.D.	N.D.	N.D.	N.D.	0.011	N.D.
40261 1YRM*	0.017	0.016	N.D.	N.D.	N.D.	0.003
40264 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40265 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40266 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40268 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40269 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40271 1YRM*	N.D.	N.D.	N.D.	N.D.	0.013	N.D.
40272 1YRM*	N.D.	N.D.	N.D.	0.002	N.D.	N.D.
40273 1YRM*	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40274 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	0.005
40276 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40277 1YRM	N.D.	N.D.	N.D.	0.021	0.007	N.D.
40279 1YRM*	N.D.	N.D.	N.D.	0.008	N.D.	N.D.
40280 1YRM*	N.D.	0.018	N.D.	N.D.	N.D.	0.002
40283 1YRM	0.008	N.D.	N.D.	N.D.	N.D.	N.D.
40284 1YRM*	N.D.	N.D.	N.D.	0.006	N.D.	N.D.
40289 1YRM*	0.012	N.D.	N.D.	N.D.	N.D.	N.D.
40290 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40291 1YRM*	0.041	N.D.	N.D.	N.D.	N.D.	N.D.
40295 1YRM*	N.D.	N.D.	N.D.	N.D.	0.005	N.D.
40297 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.008
40301 1YRM*	N.D.	0.008	N.D.	N.D.	N.D.	N.D.
40302 1YRM*	0.009	N.D.	N.D.	N.D.	N.D.	0.002
40304 1YRM	N.D.	N.D.	N.D.	0.031	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40306 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40312 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40313 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40316 1YRM*	0.004	N.D.	N.D.	N.D.	N.D.	N.D.
40320 1YRM*	N.D.	N.D.	N.D.	N.D.	0.003	N.D.
40321 1YRM*	0.021	0.007	N.D.	N.D.	N.D.	N.D.
40322 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40324 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40326 1YRM*	0.003	0.007	N.D.	0.010	N.D.	N.D.
40327 1YRM*	N.D.	0.008	N.D.	N.D.	0.004	N.D.
40329 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40334 1YRM*	0.009	0.008	N.D.	N.D.	N.D.	N.D.
40344 1YRM*	N.D.	0.008	N.D.	N.D.	N.D.	N.D.
40370 1YRM	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40382 1YRM*	N.D.	0.008	N.D.	N.D.	0.002	N.D.
40384 1YRM*	N.D.	0.019	N.D.	N.D.	N.D.	N.D.
40405 1YRM*	N.D.	N.D.	N.D.	0.016	N.D.	N.D.
40411 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40412 1YRM*	0.057	N.D.	N.D.	0.018	0.006	N.D.
40428 1YRM*	0.008	N.D.	N.D.	N.D.	N.D.	N.D.
40429 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40441 1YRM*	0.005	0.007	N.D.	N.D.	N.D.	0.011
40445 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40447 1YRM*	0.009	0.010	N.D.	N.D.	0.003	N.D.
40449 1YRM*	0.003	N.D.	N.D.	N.D.	N.D.	N.D.
40451 1YRM*	0.027	N.D.	N.D.	0.011	0.003	N.D.
40454 1YRM*	0.009	0.006	N.D.	N.D.	N.D.	N.D.
40456 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.008
40458 1YRM*	0.012	N.D.	N.D.	N.D.	N.D.	N.D.
40459 1YRM	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40460 1YRM*	N.D.	0.007	N.D.	N.D.	N.D.	N.D.
40461 1YRM*	0.025	N.D.	N.D.	0.018	N.D.	N.D.
40464 1YRM*	0.008	N.D.	N.D.	0.007	N.D.	N.D.
40465 1YRM*	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40466 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.007
40467 1YRM*	N.D.	N.D.	N.D.	N.D.	0.002	N.D.
40469 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	0.009
40470 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40474 1YRM*	0.002	0.008	N.D.	N.D.	N.D.	N.D.
40478 1YRM*	N.D.	N.D.	N.D.	0.011	N.D.	N.D.
40480 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40485 1YRM*	0.013	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40490 1YRM*	0.025	N.D.	N.D.	0.014	N.D.	N.D.
40491 1YRM*	0.022	N.D.	N.D.	N.D.	N.D.	N.D.
40492 1YRM*	N.D.	0.011	N.D.	N.D.	0.002	N.D.
40499 1YRM*	0.046	N.D.	N.D.	N.D.	N.D.	N.D.
40500 1YRM*	N.D.	N.D.	0.006	N.D.	0.004	0.001
40502 1YRM	N.D.	N.D.	N.D.	0.025	N.D.	N.D.
40509 1YRM	N.D.	N.D.	N.D.	0.024	N.D.	N.D.
40514 1YRM*	N.D.	N.D.	N.D.	N.D.	0.013	N.D.
40523 1YRM*	N.D.	N.D.	N.D.	0.012	N.D.	N.D.
40525 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40530 1YRM*	N.D.	N.D.	N.D.	N.D.	0.004	N.D.
40532 1YRM*	0.020	0.008	N.D.	N.D.	0.002	0.010
40541 1YRM*	0.017	0.009	N.D.	N.D.	0.012	0.005
40543 1YRM*	N.D.	0.008	N.D.	N.D.	0.001	N.D.
40544 1YRM*	0.016	N.D.	N.D.	0.008	N.D.	N.D.
40547 1YRM*	N.D.	N.D.	N.D.	N.D.	0.007	N.D.
40548 1YRM*	0.027	0.009	N.D.	0.007	N.D.	N.D.
40551 1YRM*	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40552 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40564 1YRM*	N.D.	N.D.	N.D.	N.D.	0.003	0.004
40568 1YRM*	N.D.	N.D.	N.D.	N.D.	0.002	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40579 1YRM*	0.016	N.D.	N.D.	N.D.	0.003	N.D.
40581 1YRM	N.D.	0.004	N.D.	N.D.	N.D.	N.D.
40586 1YRM*	0.024	N.D.	N.D.	N.D.	0.003	0.002
40587 1YRM*	N.D.	N.D.	N.D.	0.021	0.001	N.D.
40589 1YRM*	0.008	N.D.	N.D.	N.D.	N.D.	0.003
40594 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40602 1YRM*	N.D.	N.D.	N.D.	N.D.	0.006	N.D.
40605 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40607 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40611 1YRM*	0.031	N.D.	N.D.	0.009	N.D.	N.D.
40614 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40616 1YRM*	0.005	N.D.	N.D.	0.012	0.003	N.D.
40633 1YRM*	N.D.	0.003	N.D.	N.D.	0.005	N.D.
40646 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40652 1YRM*	N.D.	N.D.	N.D.	N.D.	0.006	0.011
40662 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40670 1YRM*	0.033	N.D.	N.D.	N.D.	N.D.	N.D.
40719 1YRM*	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Appendix E: Concentrations of PFCAs and PFSAs in cord blood plasma (ng/mL).

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40110 CD•	0.34	N.D.	N.D.	0.26	0.16	0.062	0.089	N.D.	0.21	1.1	0.032
40138 CD•	0.27	N.D.	N.D.	1.1	0.18	0.062	N.D.	N.D.	0.27	1.0	N.D.
40144 CD•	0.51	N.D.	0.087	0.48	0.19	N.D.	N.D.	N.D.	N.D.	0.15	N.D.
40161 CD•	0.78	N.D.	0.11	1.4	0.43	0.15	0.083	N.D.	N.D.	2.2	0.066
40185 CD•	0.79	N.D.	0.071	0.74	0.15	N.D.	0.044	N.D.	1.2	0.91	N.D.
40195 CD•	0.64	N.D.	0.067	0.22	0.11	0.038	N.D.	N.D.	N.D.	0.27	N.D.
40196 CD•	0.34	N.D.	N.D.	0.49	0.16	0.053	0.054	N.D.	0.16	0.37	N.D.
40211 CD•	1.1	N.D.	N.D.	0.52	0.18	N.D.	0.091	N.D.	0.14	0.50	N.D.
40244 CD•	0.72	N.D.	N.D.	1.7	0.24	0.066	0.053	N.D.	0.85	1.3	N.D.
40252 CD•	0.63	N.D.	0.11	0.51	0.19	N.D.	0.049	N.D.	0.13	0.57	N.D.
40254 CD•	0.56	N.D.	N.D.	0.43	0.20	0.052	0.040	N.D.	0.24	1.1	N.D.
40289 CD•	0.75	N.D.	N.D.	1.1	0.25	0.072	0.042	N.D.	N.D.	1.9	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40303 CD•	0.58	N.D.	0.097	1.6	0.28	0.075	N.D.	N.D.	0.26	1.9	N.D.
40305 CD•	0.37	N.D.	N.D.	0.97	0.36	0.17	0.16	N.D.	0.65	2.0	N.D.
40306 CD•	0.42	N.D.	N.D.	0.33	0.13	0.071	N.D.	N.D.	0.20	1.4	N.D.
40312 CD•	0.55	N.D.	N.D.	0.83	0.17	0.053	N.D.	N.D.	N.D.	0.73	N.D.
40353 CD•	0.73	N.D.	N.D.	0.99	0.23	0.079	N.D.	N.D.	0.41	1.1	N.D.
40388 CD•	0.57	N.D.	0.12	0.50	0.23	0.063	0.043	N.D.	0.30	0.87	N.D.
40392 CD•	0.56	N.D.	N.D.	1.4	0.35	N.D.	N.D.	N.D.	0.44	1.6	N.D.
40397 CD•	0.59	N.D.	N.D.	0.38	N.D.	0.036	N.D.	N.D.	0.30	0.33	N.D.
40415 CD•	0.63	N.D.	0.081	0.68	0.15	N.D.	N.D.	N.D.	0.72	0.58	N.D.
40432 CD•	0.58	N.D.	N.D.	1.6	0.53	0.27	0.079	N.D.	0.31	1.7	N.D.
40434 CD•	0.33	N.D.	N.D.	0.38	0.21	0.11	0.13	N.D.	0.12	1.1	N.D.
40447 CD•	0.71	N.D.	N.D.	0.45	0.15	0.055	N.D.	N.D.	0.55	1.5	N.D.
40451 CD•	0.88	N.D.	N.D.	0.19	0.086	N.D.	0.043	N.D.	0.19	0.27	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40454 CD•	0.80	N.D.	N.D.	0.63	0.16	0.066	0.040	N.D.	0.32	0.83	N.D.
40456 CD•	0.26	N.D.	0.13	1.1	0.22	0.059	N.D.	N.D.	0.31	0.64	N.D.
40461 CD•	0.33	N.D.	0.11	0.95	N.D.	0.066	N.D.	N.D.	N.D.	0.61	N.D.
40475 CD•	0.30	N.D.	N.D.	1.3	0.31	0.078	N.D.	N.D.	0.78	1.4	N.D.
40478 CD•	0.62	N.D.	N.D.	0.34	0.15	0.050	0.046	N.D.	0.35	0.46	N.D.
40489 CD•	0.52	N.D.	N.D.	0.66	0.14	0.043	N.D.	N.D.	0.13	1.7	N.D.
40490 CD•	0.23	N.D.	N.D.	0.56	0.12	0.053	0.041	N.D.	0.13	0.48	N.D.
40522 CD•	0.43	N.D.	N.D.	0.60	0.16	N.D.	N.D.	N.D.	0.20	0.69	N.D.
40532 CD•	0.70	N.D.	N.D.	0.37	0.096	0.051	N.D.	N.D.	0.19	0.31	N.D.
40537 CD•	0.49	N.D.	N.D.	0.23	0.12	N.D.	N.D.	N.D.	N.D.	0.23	N.D.
40556 CD•	0.65	N.D.	0.097	0.32	N.D.	N.D.	0.058	N.D.	0.30	0.68	N.D.
40557 CD•	0.31	N.D.	0.099	0.22	N.D.	N.D.	N.D.	N.D.	0.26	0.21	N.D.
40559 CD•	0.38	N.D.	0.10	0.37	0.13	0.054	0.043	N.D.	0.16	0.56	N.D.

Sample ID	Analyte										
	PFPA	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
40573 CD•	0.35	N.D.	0.11	0.80	0.26	0.071	0.039	N.D.	3.7	2.7	N.D.
40579 CD•	0.36	0.11	N.D.	0.53	0.25	0.064	N.D.	N.D.	0.25	0.91	N.D.
40580 CD•	0.41	0.15	N.D.	0.27	N.D.	N.D.	N.D.	N.D.	N.D.	0.31	N.D.
40586 CD•	0.28	0.11	0.077	0.81	0.78	0.21	0.20	N.D.	0.43	2.7	N.D.
40605 CD•	0.68	N.D.	N.D.	0.69	0.22	N.D.	N.D.	N.D.	0.18	0.68	N.D.
40611 CD•	0.66	0.18	N.D.	0.68	0.12	0.053	N.D.	N.D.	1.3	0.90	N.D.
40630 CD•	0.52	N.D.	0.076	0.51	0.12	0.054	N.D.	N.D.	0.38	0.44	N.D.
40652 CD•	0.49	N.D.	0.086	0.68	0.25	0.065	0.055	N.D.	0.42	0.79	N.D.
40656 CD•	0.27	0.12	N.D.	0.75	0.16	0.055	0.045	N.D.	0.92	1.6	N.D.
40661 CD•	0.46	N.D.	N.D.	0.63	0.095	N.D.	N.D.	N.D.	0.38	0.37	N.D.
40710 CD•	0.33	N.D.	N.D.	0.39	0.17	N.D.	0.054	N.D.	0.34	0.80	N.D.
40719 CD•	0.32	N.D.	0.092	0.31	N.D.	N.D.	0.055	N.D.	N.D.	0.31	N.D.

Appendix F: Concentrations of 8:2 FTUCA, FOSAs and FOSEs in cord blood plasma (ng/mL).

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40110 CD•	N.D.	N.D.	N.D.	0.077	N.D.	N.D.
40138 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40144 CD•	N.D.	N.D.	N.D.	0.011	N.D.	N.D.
40161 CD•	0.043	N.D.	N.D.	N.D.	N.D.	N.D.
40185 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40195 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40196 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40211 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40244 CD•	0.023	N.D.	N.D.	N.D.	N.D.	N.D.
40252 CD•	0.023	N.D.	N.D.	0.007	N.D.	N.D.
40254 CD•	N.D.	0.006	N.D.	N.D.	N.D.	N.D.
40289 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40303 CD•	0.024	N.D.	N.D.	N.D.	N.D.	0.003
40305 CD•	0.017	N.D.	N.D.	N.D.	N.D.	N.D.
40306 CD•	0.021	0.008	N.D.	N.D.	0.001	N.D.
40312 CD•	0.031	N.D.	N.D.	N.D.	N.D.	0.016
40353 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40388 CD•	0.035	N.D.	N.D.	N.D.	N.D.	N.D.
40392 CD•	0.029	N.D.	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	FOSA	MeFOSA	EtFOSA	MeFOSE	EtFOSE
40397 CD•	0.021	0.007	N.D.	0.014	N.D.	0.015
40415 CD•	0.027	0.008	N.D.	N.D.	N.D.	N.D.
40432 CD•	0.019	N.D.	N.D.	0.005	N.D.	0.014
40434 CD•	0.016	N.D.	N.D.	N.D.	N.D.	N.D.
40447 CD•	N.D.	0.008	N.D.	N.D.	N.D.	0.013
40451 CD•	0.042	N.D.	N.D.	N.D.	N.D.	0.018
40454 CD•	0.035	N.D.	N.D.	0.078	0.004	0.029
40456 CD•	0.048	N.D.	N.D.	N.D.	N.D.	N.D.
40461 CD•	0.031	0.019	N.D.	N.D.	0.004	N.D.
40475 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40478 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	0.006
40489 CD•	N.D.	N.D.	N.D.	0.023	N.D.	N.D.
40490 CD•	0.018	N.D.	N.D.	0.019	N.D.	N.D.
40522 CD•	N.D.	N.D.	N.D.	0.020	N.D.	N.D.
40532 CD•	0.019	0.019	N.D.	0.047	0.002	0.009
40537 CD•	0.021	N.D.	N.D.	N.D.	N.D.	N.D.
40556 CD•	0.020	N.D.	N.D.	N.D.	N.D.	N.D.
40557 CD•	0.026	N.D.	N.D.	N.D.	N.D.	N.D.
40559 CD•	0.033	N.D.	N.D.	N.D.	N.D.	N.D.
40573 CD•	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
40579 CD•	0.018	0.018	N.D.	N.D.	N.D.	N.D.

Sample ID	Analyte					
	FTUCA	**FOSA**	**MeFOSA**	**EtFOSA**	**MeFOSE**	**EtFOSE**
40580 CD•	N.D.	N.D.	N.D.	0.021	N.D.	N.D.
40586 CD•	0.011	N.D.	N.D.	N.D.	N.D.	N.D.
40605 CD•	N.D.	0.018	N.D.	N.D.	N.D.	0.005
40611 CD•	0.031	N.D.	N.D.	N.D.	0.003	N.D.
40630 CD•	0.024	0.019	N.D.	N.D.	N.D.	0.002
40652 CD•	N.D.	0.018	N.D.	N.D.	N.D.	N.D.
40656 CD•	0.014	N.D.	N.D.	N.D.	N.D.	N.D.
40661 CD•	N.D.	N.D.	N.D.	N.D.	0.001	N.D.
40710 CD•	N.D.	N.D.	N.D.	N.D.	0.001	0.003
40719 CD•	0.024	N.D.	N.D.	N.D.	0.003	N.D.

Appendix G: PCA factor scores for maternal plasma during pregnancy and one year after delivery.

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40074 PNM*	1.5	-1.6	-0.38
40091 PNM	0.51	0.23	-1.7
40110 PNM*	0.67	1.34	0.91
40124 PNM*	0.51	-1.6	-0.39
40134 PNM*	1.5	-0.31	-0.24
40138 PNM*	1.2	-2.3	-1.5
40139 PNM*	-0.10	-0.10	-0.12
40140 PNM*	0.25	-1.2	-0.18
40142 PNM*	1.2	-0.65	0.089
40143 PNM*	0.14	-0.44	0.13
40144 PNM*	0.82	-0.23	-0.51
40145 PNM	0.12	0.38	-0.074
40146 PNM*	0.90	2.89	2.6
40147 PNM*	0.72	-0.00084	-0.42
40148 PNM*	-0.29	1.28	-1.0
40149 PNM	1.7	-1.1	-0.72
40150 PNM*	0.44	-0.20	-0.085
40151 PNM	-1.9	0.43	0.69
40156 PNM*	0.98	0.29	0.074

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40157 PNM*	-0.13	1.25	0.16
40158 PNM*	0.51	-0.093	-0.60
40159 PNM*	0.56	0.75	0.059
40160 PNM	-0.40	-0.14	-0.80
40161 PNM*	1.0	1.10	0.49
40162 PNM*	1.1	-0.11	0.41
40163 PNM	0.0063	0.84	-0.47
40164 PNM*	-1.4	1.15	0.87
40165 PNM	1.8	0.64	0.59
40166 PNM*	0.57	-0.0051	-0.45
40167 PNM	-0.68	0.10	-0.61
40168 PNM	0.59	-0.91	-1.5
40169 PNM*	-0.34	2.14	-0.49
40170 PNM*	-0.088	0.50	-0.35
40171 PNM	-1.9	-1.1	-0.0014
40172 PNM*	-0.29	-0.23	-0.60
40173 PNM	0.82	-0.74	-0.0030
40175 PNM*	0.22	0.68	-1.0
40176 PNM*	0.082	0.56	-0.47
40177 PNM*	-1.9	-0.39	-0.42
40178 PNM*	-1.5	0.72	-0.47

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40179 PNM*	-0.86	0.49	0.13
40180 PNM*	0.17	0.75	-0.10
40181 PNM	-0.64	-0.27	-0.45
40185 PNM*	0.66	-1.4	-0.061
40186 PNM*	-0.65	0.17	-0.71
40187 PNM*	-0.25	0.64	-0.18
40188 PNM*	0.37	0.72	-0.68
40190 PNM*	1.8	-1.2	-0.62
40192 PNM*	0.52	0.77	1.5
40193 PNM*	0.80	-0.24	0.75
40194 PNM*	0.95	-1.5	-2.1
40195 PNM*	-1.2	0.79	-0.10
40196 PNM*	-0.44	-0.30	-1.2
40197 PNM*	0.23	1.14	0.24
40198 PNM*	0.48	0.025	-1.3
40203 PNM*	-1.1	0.35	0.18
40204 PNM	0.44	0.16	0.28
40205 PNM*	0.61	-0.051	-0.010
40206 PNM*	-0.53	0.14	-0.14
40209 PNM*	-1.1	1.09	0.20
40210 PNM	-0.75	1.63	-0.41

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40211 PNM*	0.22	-0.0037	0.55
40212 PNM	0.070	-0.60	-0.076
40213 PNM	0.52	-0.13	-1.4
40215 PNM	-0.091	0.32	-0.50
40218 PNM*	0.24	-0.083	-0.79
40224 PNM	0.48	0.40	-0.27
40225 PNM*	0.25	0.57	0.27
40226 PNM	1.4	-0.40	-3.1
40227 PNM	-0.11	0.15	-0.79
40228 PNM	-1.6	1.25	-0.10
40232 PNM*	0.62	0.22	-0.85
40235 PNM*	0.27	-0.11	0.68
40241 PNM	1.2	-0.53	-0.057
40243 PNM*	0.99	0.88	0.54
40244 PNM*	0.0043	1.06	-4.2
40245 PNM*	0.42	0.59	-0.25
40246 PNM*	0.082	-0.47	-0.90
40247 PNM*	1.8	-0.95	-0.18
40248 PNM	-0.29	1.29	0.12
40249 PNM	-0.035	0.93	0.65
40250 PNM*	0.39	1.18	-1.5

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40252 PNM*	-0.32	0.60	-0.84
40254 PNM*	0.043	0.13	-0.38
40255 PNM*	-2.4	0.10	0.17
40256 PNM*	1.4	0.49	0.71
40257 PNM*	-2.8	1.69	-0.36
40258 PNM*	0.065	0.64	-0.26
40259 PNM*	-0.35	-0.52	-1.6
40260 PNM	-0.039	0.48	-0.96
40261 PNM*	0.22	0.59	-0.28
40264 PNM*	-0.27	0.41	0.28
40265 PNM*	0.27	1.40	0.57
40268 PNM*	-1.3	0.058	-0.87
40269 PNM*	0.061	-0.23	-0.19
40271 PNM*	0.87	1.12	-0.28
40272 PNM*	0.18	0.48	0.078
40273 PNM*	-1.3	0.13	-0.43
40274 PNM*	-0.043	0.057	-0.48
40275 PNM	-1.3	-1.2	-1.2
40276 PNM*	0.46	-0.51	-0.55
40279 PNM*	-0.75	1.00	-0.40
40280 PNM*	0.70	-0.45	-0.51

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40284 PNM*	1.8	-1.5	-0.63
40287 PNM	-0.60	0.44	-0.40
40288 PNM	0.20	0.028	0.49
40289 PNM*	-0.057	-0.66	-0.50
40290 PNM*	1.1	-2.0	-1.5
40291 PNM*	-1.1	-0.43	-0.81
40295 PNM*	-1.2	-0.63	-0.31
40296 PNM	-0.99	-0.94	-0.46
40297 PNM*	0.85	0.78	-0.053
40300 PNM	-0.85	0.86	0.17
40301 PNM*	0.28	-1.3	-0.011
40302 PNM*	0.54	-0.55	-0.81
40303 PNM	1.2	-1.0	-0.55
40305 PNM	-0.20	1.23	-0.50
40306 PNM*	-0.19	0.30	-0.13
40311 PNM	-0.57	-0.30	1.0
40312 PNM*	0.30	0.31	-0.044
40313 PNM*	1.2	-0.15	-1.1
40315 PNM	-0.24	0.46	-0.81
40316 PNM*	-0.74	-0.057	-0.46
40317 PNM	0.38	0.20	-1.2

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40318 PNM	0.83	0.88	0.68
40319 PNM	-2.0	1.35	-2.5
40320 PNM*	-1.5	-1.0	-0.96
40321 PNM*	0.47	1.22	1.0
40322 PNM*	1.7	-1.7	-1.3
40323 PNM	0.69	0.30	0.17
40324 PNM*	1.0	0.90	0.067
40325 PNM	2.3	1.05	2.1
40326 PNM*	-0.60	-0.076	0.23
40327 PNM*	2.6	0.015	0.071
40328 PNM	0.030	0.70	-3.3
40329 PNM*	-0.29	-0.086	1.6
40330 PNM	0.10	1.73	0.96
40331 PNM	0.47	0.15	0.10
40332 PNM	0.62	1.17	-0.36
40333 PNM	-2.3	0.37	-1.2
40334 PNM*	-0.084	1.04	0.43
40335 PNM	1.6	-1.2	-0.60
40336 PNM	-0.60	0.074	-0.55
40338 PNM	1.1	0.20	-1.4
40342 PNM	-0.84	0.52	-1.4

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40343 PNM	0.51	0.69	0.30
40344 PNM*	1.8	0.43	0.54
40345 PNM	-0.19	1.37	-0.14
40346 PNM	2.1	0.13	0.033
40347 PNM	-0.63	1.05	-0.061
40349 PNM	-0.21	-0.38	-0.25
40350 PNM	0.43	1.76	-0.034
40352 PNM	1.0	-0.030	0.32
40353 PNM	0.12	-1.3	0.23
40354 PNM	-0.68	0.51	0.14
40357 PNM	0.38	-0.39	1.3
40358 PNM	0.028	1.64	-0.66
40359 PNM	-0.0017	0.21	0.63
40360 PNM	1.2	-0.10	-0.38
40361 PNM	0.24	1.52	-1.4
40362 PNM	1.2	-1.6	0.67
40364 PNM	0.23	0.27	1.5
40365 PNM	1.7	-0.60	-0.013
40366 PNM	0.24	1.27	-0.082
40369 PNM	-0.31	0.34	-1.5
40371 PNM	-0.86	-0.82	-1.1

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40372 PNM	0.44	-0.42	-0.43
40375 PNM	-0.98	0.65	-0.15
40376 PNM	-2.0	0.30	-0.89
40378 PNM	-0.23	-1.7	-0.16
40379 PNM	1.1	-0.63	-0.14
40381 PNM	0.38	-0.71	0.88
40382 PNM*	0.45	0.42	0.12
40384 PNM*	-0.50	-0.18	0.28
40386 PNM	-1.1	0.074	0.41
40388 PNM	0.24	0.29	0.19
40390 PNM	2.4	-4.7	-1.5
40392 PNM	0.86	0.23	0.45
40393 PNM	-0.87	1.36	-0.77
40395 PNM	1.0	2.22	0.76
40396 PNM	0.32	0.48	0.69
40397 PNM	-0.0042	0.62	0.17
40399 PNM	-1.5	0.94	-1.0
40401 PNM	0.32	-0.41	-0.58
40405 PNM*	0.48	-1.8	0.52
40406 PNM	-1.8	0.50	-1.1
40409 PNM	-1.1	1.13	1.1

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40411 PNM*	-0.26	-0.59	-0.17
40412 PNM*	-0.21	-0.12	0.57
40413 PNM	-0.97	-1.1	-1.3
40415 PNM	0.71	0.98	-0.71
40416 PNM	0.34	1.60	-0.26
40417 PNM	-0.32	0.036	0.16
40418 PNM	0.19	0.37	-0.56
40419 PNM	0.060	0.65	-0.17
40420 PNM	-1.2	-0.30	0.063
40421 PNM	1.5	-0.80	-0.51
40422 PNM	0.74	0.58	-0.21
40424 PNM	0.39	0.26	-0.33
40425 PNM	-0.99	0.014	-0.21
40428 PNM*	1.2	-0.27	0.36
40429 PNM*	-0.39	0.76	-0.35
40430 PNM	-1.5	0.47	-0.27
40432 PNM	0.86	-0.076	-2.0
40433 PNM	0.093	0.059	-1.4
40434 PNM	0.010	0.79	-1.1
40436 PNM	-0.95	0.85	-1.5
40438 PNM	1.0	1.05	-0.30

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40439 PNM	-0.024	1.14	-0.35
40440 PNM	0.42	1.50	0.56
40441 PNM*	0.47	-0.032	-0.10
40442 PNM	0.31	0.86	-0.75
40443 PNM	-0.28	1.10	-2.9
40444 PNM	0.10	0.18	-0.95
40445 PNM*	-0.15	-0.55	-0.92
40446 PNM	-1.4	0.70	-0.29
40447 PNM*	-1.7	-0.073	1.7
40449 PNM*	-0.32	0.089	-1.4
40451 PNM*	0.99	0.29	-0.32
40453 PNM	1.0	0.35	0.077
40454 PNM*	0.33	-0.23	-1.0
40455 PNM	0.30	-0.56	-0.56
40456 PNM*	0.57	0.21	-0.99
40457 PNM	-0.036	0.056	-0.37
40458 PNM*	-0.15	0.53	-0.40
40460 PNM*	-1.5	1.17	0.10
40461 PNM*	0.69	-0.0047	0.52
40462 PNM	-0.59	0.23	-1.1
40463 PNM	2.6	0.69	1.7

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40464 PNM*	-0.32	0.020	-0.69
40465 PNM*	1.0	-0.67	-0.23
40466 PNM*	-0.094	-2.1	-0.84
40467 PNM*	1.3	2.79	0.31
40468 PNM	-0.79	0.54	0.74
40469 PNM*	0.30	0.72	1.1
40470 PNM*	0.33	0.43	-1.2
40471 PNM	1.2	-1.8	-0.23
40472 PNM	-0.24	-0.49	-1.3
40474 PNM*	-1.5	-1.2	0.47
40475 PNM	0.70	1.13	0.055
40476 PNM	1.5	0.45	-0.27
40478 PNM*	0.49	-0.76	-0.41
40480 PNM*	0.76	0.13	1.0
40481 PNM	-2.3	0.40	0.15
40482 PNM	-0.67	-0.34	-0.19
40483 PNM	-0.72	-0.040	-0.42
40485 PNM*	0.26	0.35	0.32
40489 PNM	0.019	0.42	0.46
40490 PNM*	-0.73	0.80	-0.44
40491 PNM*	0.91	-0.085	-0.51

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40492 PNM*	-0.38	-3.1	-1.2
40494 PNM	0.21	0.21	-0.11
40495 PNM	-0.14	0.61	0.93
40496 PNM	-1.2	-0.54	0.15
40497 PNM	0.79	2.41	0.71
40498 PNM	-1.6	0.66	-0.65
40499 PNM*	0.093	1.74	-0.76
40500 PNM*	0.85	-1.1	-0.50
40504 PNM	0.017	1.01	-0.29
40505 PNM	0.090	0.97	0.20
40506 PNM	0.43	-0.72	0.29
40507 PNM	0.36	-0.28	-0.68
40508 PNM	0.024	0.92	-0.89
40514 PNM*	-0.42	0.16	-0.22
40517 PNM	-0.13	1.71	0.68
40518 PNM	0.40	0.29	-0.67
40521 PNM	0.017	-0.20	-1.3
40522 PNM	0.15	0.64	0.40
40523 PNM*	-0.60	-0.60	-0.99
40525 PNM*	0.40	0.094	-0.32
40526 PNM	0.66	0.81	0.16

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40527 PNM	-1.2	0.39	-0.81
40528 PNM	0.50	-0.23	-0.22
40529 PNM	0.14	0.088	-1.1
40530 PNM*	-1.1	0.83	-0.16
40532 PNM*	2.0	-0.27	0.42
40533 PNM	0.25	1.32	-1.1
40535 PNM	-1.9	-0.64	-0.91
40537 PNM	-0.062	-0.20	-0.60
40538 PNM	-0.56	0.56	-1.2
40539 PNM	0.74	0.42	0.0070
40541 PNM*	0.22	1.04	-0.0030
40542 PNM	0.67	0.26	0.55
40543 PNM*	0.33	0.38	-0.25
40544 PNM*	0.83	-0.11	0.52
40545 PNM	-0.80	-0.10	0.040
40547 PNM*	-0.79	0.70	3.4
40548 PNM*	0.056	0.28	-0.60
40549 PNM	0.45	0.74	-0.42
40551 PNM*	-0.78	0.61	-0.64
40552 PNM*	0.68	0.39	-1.4
40554 PNM	1.3	-0.071	-1.1

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40556 PNM	-0.22	0.38	-0.71
40557 PNM	2.3	-0.45	-1.2
40558 PNM	0.018	-0.33	0.76
40559 PNM	-0.33	0.17	-1.5
40560 PNM	0.66	0.45	0.77
40561 PNM	0.13	0.46	-1.4
40563 PNM	0.56	-0.083	0.25
40564 PNM*	0.20	0.10	-0.42
40566 PNM	2.1	2.48	1.0
40568 PNM*	-0.61	0.18	1.6
40571 PNM	0.27	0.82	1.1
40573 PNM	-0.93	-0.47	-2.3
40575 PNM	-0.38	0.37	-1.5
40576 PNM	0.46	0.55	0.31
40579 PNM*	0.79	-0.30	0.092
40580 PNM	0.049	1.38	-0.087
40583 PNM	-0.85	0.80	0.83
40584 PNM	-0.87	-0.86	-2.9
40586 PNM*	0.42	-0.11	-0.015
40587 PNM*	-0.70	0.99	0.18
40588 PNM	0.15	1.54	-0.51

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40589 PNM*	-0.28	0.73	-0.42
40590 PNM	1.7	0.76	-0.53
40592 PNM	0.090	0.67	-0.10
40593 PNM	0.48	0.91	-0.91
40594 PNM*	-0.70	0.36	-0.26
40600 PNM	-0.16	0.76	-1.7
40602 PNM*	-0.29	-0.10	-0.14
40603 PNM	0.17	-0.11	-0.31
40604 PNM	-0.10	0.93	-0.99
40605 PNM*	0.35	2.73	0.68
40607 PNM*	-0.43	0.007	-0.77
40611 PNM*	0.54	1.58	0.80
40612 PNM	1.2	2.64	-0.21
40613 PNM	-0.27	1.02	-0.23
40614 PNM*	-0.82	0.97	-0.81
40616 PNM*	1.3	-1.5	-0.40
40620 PNM	-0.51	1.38	-0.91
40623 PNM	0.17	0.19	-1.2
40625 PNM	1.4	1.30	-0.039
40628 PNM	0.88	2.39	0.93
40629 PNM	-0.23	0.20	-0.10

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40630 PNM	2.2	-0.25	-0.95
40631 PNM	0.48	1.33	-1.4
40632 PNM	-2.1	0.16	-1.6
40633 PNM*	1.6	2.88	0.87
40644 PNM	-0.17	0.28	-0.16
40646 PNM*	0.034	1.05	1.1
40647 PNM	0.45	-0.62	-0.14
40648 PNM	0.15	0.22	0.63
40649 PNM	-1.5	-0.32	-1.2
40650 PNM	0.64	0.81	-1.1
40651 PNM	-0.99	-0.64	-0.91
40652 PNM*	-0.66	0.043	-0.62
40653 PNM	2.0	1.81	-3.3
40654 PNM	-0.88	1.76	0.77
40656 PNM	-0.42	0.56	0.32
40659 PNM	-1.5	-1.4	-1.7
40661 PNM	0.93	1.00	0.48
40662 PNM*	-0.55	-0.19	-0.49
40663 PNM	-1.6	0.079	-0.65
40664 PNM	-0.38	-0.90	-1.0
40665 PNM	-0.71	0.77	-0.90

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40667 PNM	-0.30	1.05	-1.3
40668 PNM	0.87	1.71	0.45
40669 PNM	-0.55	2.27	-0.47
40670 PNM*	0.015	-0.69	-2.0
40671 PNM	-0.87	-1.7	-0.98
40673 PNM	-0.86	1.12	-1.2
40674 PNM	0.45	1.00	-0.96
40676 PNM	-0.80	0.69	-0.052
40677 PNM	0.056	0.29	-0.90
40680 PNM	-0.50	0.68	1.1
40683 PNM	1.8	-0.54	0.53
40686 PNM	0.53	0.37	-1.1
40688 PNM	0.36	-0.60	-0.46
40689 PNM	-0.084	-0.54	-0.24
40690 PNM	-0.19	0.39	-0.52
40691 PNM	-0.055	0.36	-0.48
40692 PNM	-0.84	-0.63	-1.8
40693 PNM	-0.40	0.87	0.57
40694 PNM	-0.55	0.82	-1.1
40695 PNM	0.31	0.14	-0.48
40696 PNM	-0.66	-0.52	-0.42

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40697 PNM	-0.32	0.87	-1.9
40698 PNM	1.0	2.77	0.26
40699 PNM	1.1	0.77	-0.043
40704 PNM	0.75	-0.47	-0.32
40705 PNM	-0.20	1.93	-0.29
40706 PNM	-0.36	-0.0028	-1.3
40707 PNM	2.4	-3.2	-4.2
40708 PNM	-2.8	2.96	-5.8
40709 PNM	0.52	-0.15	-0.87
40710 PNM	0.46	1.31	0.76
40711 PNM	1.2	-0.031	0.084
40712 PNM	0.43	-0.019	-1.4
40713 PNM	0.023	0.59	-0.59
40718 PNM	1.7	0.11	1.0
40719 PNM*	0.74	-0.059	-0.52
40720 PNM	-0.61	0.82	-1.1
40722 PNM	0.074	-0.21	-0.11
40723 PNM	-0.22	1.69	-0.32
40724 PNM	0.66	0.83	-0.26
40725 PNM	0.31	-1.2	-2.0
40726 PNM	1.1	-0.60	0.61

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40727 PNM	0.70	0.80	0.70
40730 PNM	-1.7	-0.83	-0.62
40731 PNM	0.41	-1.2	-1.1
40732 PNM	1.4	0.44	-0.055
40739 PNM	-0.19	1.10	-1.7
40740 PNM	-0.27	0.17	-1.2
40745 PNM	0.64	-0.11	0.79
40792 PNM	1.4	-1.2	-0.70
40834 PNM	-0.97	-1.7	2.1
40890 PNM	0.32	0.44	0.94
40891 PNM	0.88	-1.1	0.050
40893 PNM	-1.1	-0.055	0.024
40894 PNM	0.69	1.08	0.91
40925 PNM	-1.2	0.37	0.011
40931 PNM	-1.3	-0.66	0.12
40955 PNM	0.93	-0.074	0.56
41077 PNM	-0.52	0.10	0.35
40004 1YRM	0.83	-0.16	0.93
40013 1YRM	0.81	-0.76	0.74
40014 1YRM	-0.70	0.28	0.89
40016 1YRM	0.58	-0.40	0.77

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40024 1YRM	-0.34	-1.1	-0.38
40025 1YRM	-3.1	-4.7	0.46
40027 1YRM	0.49	-0.071	2.1
40028 1YRM	-0.044	-0.41	1.2
40030 1YRM	0.58	-0.90	1.2
40032 1YRM	1.3	0.39	0.66
40033 1YRM	-0.56	-3.6	0.039
40036 1YRM	0.16	0.18	-0.076
40040 1YRM	-0.25	0.38	0.096
40043 1YRM	-1.9	-0.78	1.3
40047 1YRM	-0.36	0.67	0.25
40048 1YRM	-1.5	0.17	1.5
40051 1YRM	-2.3	-1.1	0.96
40052 1YRM	-0.12	0.85	1.2
40054 1YRM	-0.52	-0.68	-0.35
40057 1YRM	-0.11	-1.1	0.25
40060 1YRM	0.78	-0.38	0.60
40062 1YRM	-0.77	-0.50	2.0
40064 1YRM	-0.24	-0.53	0.25
40065 1YRM	0.20	-0.34	1.5
40066 1YRM	0.39	-0.12	0.66

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40067 1YRM	-1.6	0.71	0.43
40069 1YRM	-0.12	1.7	1.4
40071 1YRM	0.28	1.6	0.56
40074 1YRM*	0.83	-0.44	0.57
40076 1YRM	-0.76	-1.7	1.1
40077 1YRM	-0.19	-0.35	-0.028
40078 1YRM	-0.075	-0.46	2.1
40081 1YRM	0.30	0.73	1.6
40082 1YRM	-0.21	1.4	0.95
40083 1YRM	0.071	0.61	0.16
40085 1YRM	-0.55	-0.26	0.24
40086 1YRM	1.5	-1.4	-0.052
40087 1YRM	0.31	1.4	0.47
40089 1YRM	0.88	-1.7	1.0
40090 1YRM	-0.58	-0.43	0.88
40092 1YRM	-1.2	-1.4	0.92
40094 1YRM	0.067	-2.0	0.67
40095 1YRM	0.60	-0.81	0.62
40097 1YRM	-3.1	-1.6	1.7
40098 1YRM	-0.063	0.13	0.49
40099 1YRM	-0.11	-0.36	1.2

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40100 1YRM	0.41	-0.19	0.77
40101 1YRM	-1.5	0.75	2.1
40102 1YRM	-1.6	1.3	-0.37
40103 1YRM	-0.33	-0.62	0.89
40104 1YRM	-1.1	-1.0	0.96
40105 1YRM	0.83	-0.63	0.43
40106 1YRM	-0.58	-1.2	0.58
40107 1YRM	0.27	-1.2	0.12
40110 1YRM*	-0.66	-0.22	0.50
40111 1YRM	0.49	0.26	0.49
40114 1YRM	-0.80	1.7	1.3
40115 1YRM	0.35	-1.1	0.60
40116 1YRM	-0.95	-0.36	0.76
40117 1YRM	0.51	0.48	2.5
40118 1YRM	-0.099	-0.30	2.0
40120 1YRM	-0.44	-1.3	0.59
40123 1YRM	-0.89	-0.43	1.4
40124 1YRM*	-0.38	-0.18	-0.12
40126 1YRM	0.32	-0.71	0.79
40128 1YRM	-1.7	-0.99	1.0
40129 1YRM	0.097	1.9	1.7

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40132 1YRM	-0.067	0.55	0.64
40134 1YRM*	1.4	0.19	0.35
40135 1YRM	0.65	1.1	0.27
40136 1YRM	-1.5	-0.54	0.35
40137 1YRM	0.21	0.052	-0.26
40138 1YRM*	0.52	-0.85	-0.34
40139 1YRM*	0.0022	-0.61	0.25
40140 1YRM*	-0.77	-0.26	-1.3
40141 1YRM	-0.32	-0.33	2.0
40142 1YRM*	-1.3	-0.41	0.16
40143 1YRM*	-1.7	0.57	0.62
40144 1YRM*	1.4	-2.5	-1.6
40146 1YRM*	0.77	-1.0	1.2
40147 1YRM*	-1.3	-0.12	-0.92
40148 1YRM*	-2.0	0.25	0.75
40150 1YRM*	1.6	-2.0	-0.23
40156 1YRM*	-0.37	-0.50	0.059
40157 1YRM*	0.38	-0.79	0.28
40158 1YRM*	0.49	0.18	0.058
40159 1YRM*	0.39	0.94	-0.18
40161 1YRM*	0.24	0.046	1.5

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40162 1YRM*	-2.0	0.33	0.53
40164 1YRM*	0.96	-0.24	1.1
40166 1YRM*	0.85	0.14	-0.24
40169 1YRM*	0.18	0.18	-0.32
40170 1YRM*	0.70	-1.6	0.72
40172 1YRM*	-1.7	-0.44	0.67
40174 1YRM	0.95	-0.32	1.3
40175 1YRM*	-0.95	-0.20	0.35
40176 1YRM*	-0.54	-0.42	3.3
40177 1YRM*	1.1	-0.67	0.64
40178 1YRM*	1.2	-2.4	0.60
40179 1YRM*	0.15	1.4	0.31
40180 1YRM*	0.68	0.63	-1.5
40183 1YRM	1.0	-1.3	0.25
40184 1YRM	-0.20	0.21	0.18
40185 1YRM*	0.27	-1.3	-1.0
40186 1YRM*	0.43	-0.69	-1.0
40187 1YRM*	0.91	-0.51	0.18
40188 1YRM*	-0.43	-0.047	1.4
40189 1YRM	-0.90	-1.1	1.9
40190 1YRM*	-0.099	-1.0	-0.66

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40192 1YRM*	1.3	-0.35	0.15
40193 1YRM*	-1.2	-0.34	0.92
40194 1YRM*	-1.4	-0.74	0.16
40195 1YRM*	-1.3	0.70	-1.7
40196 1YRM*	-0.23	0.030	-0.37
40197 1YRM*	-0.079	-0.47	-0.37
40198 1YRM*	-0.30	-1.5	-1.4
40203 1YRM*	0.70	-0.48	0.28
40205 1YRM*	2.1	-0.19	1.8
40206 1YRM*	-1.5	-0.91	-0.10
40207 1YRM	0.13	-1.6	2.2
40209 1YRM*	0.80	-0.37	1.4
40211 1YRM*	1.1	-0.077	0.22
40216 1YRM	0.47	-0.18	1.9
40218 1YRM*	-2.4	-1.2	0.42
40225 1YRM*	-0.25	0.68	-1.1
40232 1YRM*	0.98	0.079	0.025
40235 1YRM*	-2.0	-1.4	-0.99
40239 1YRM	-0.92	0.86	-0.028
40240 1YRM	0.25	-0.15	0.87
40243 1YRM*	-2.7	0.29	0.28

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40244 1YRM*	-0.66	-1.7	0.48
40245 1YRM*	0.94	-2.0	0.087
40246 1YRM*	0.12	0.054	1.3
40247 1YRM*	0.79	-0.84	0.42
40250 1YRM*	-0.58	-0.45	-0.085
40252 1YRM*	0.23	0.45	-0.25
40254 1YRM*	0.19	-0.0037	-0.29
40255 1YRM*	0.73	0.61	1.3
40256 1YRM*	-1.9	0.18	0.039
40257 1YRM*	0.54	-0.014	0.81
40258 1YRM*	1.6	-1.8	0.26
40259 1YRM*	0.23	-1.8	1.9
40261 1YRM*	-6.0	-2.9	1.1
40264 1YRM*	-0.22	-0.48	0.40
40265 1YRM*	0.32	-1.2	1.4
40266 1YRM	-2.1	0.12	0.88
40268 1YRM*	1.1	-3.3	-1.2
40269 1YRM*	-0.073	-1.6	-0.66
40271 1YRM*	-1.5	0.82	-0.081
40272 1YRM*	-0.039	-0.72	1.4
40273 1YRM*	0.18	-0.94	0.93

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40274 1YRM*	-0.16	-0.99	-0.12
40276 1YRM*	0.97	-1.8	0.13
40277 1YRM	1.0	0.29	1.4
40279 1YRM*	-0.68	0.40	0.33
40280 1YRM*	0.31	-1.8	0.55
40283 1YRM	0.064	-0.30	0.49
40284 1YRM*	1.0	-0.76	-0.084
40289 1YRM*	0.033	0.36	3.1
40290 1YRM*	-0.072	0.33	0.17
40291 1YRM*	0.28	-0.51	0.94
40295 1YRM*	1.1	-0.39	0.43
40297 1YRM*	-0.36	-0.62	0.42
40301 1YRM*	0.39	0.42	0.93
40302 1YRM*	-0.78	-0.51	0.32
40304 1YRM	-0.000017	0.31	1.4
40306 1YRM*	0.32	2.6	1.2
40312 1YRM*	0.61	-1.4	0.48
40313 1YRM*	0.41	0.038	0.79
40316 1YRM*	0.040	-0.70	-0.57
40320 1YRM*	0.37	-0.16	-0.37
40321 1YRM*	-2.4	0.19	0.16

Sample ID	PCA Factor Score		
	PC1	PC2	PC3
40322 1YRM*	0.82	-1.1	0.56
40324 1YRM*	0.019	-0.44	0.84
40326 1YRM*	-4.7	-1.9	0.58
40327 1YRM*	-0.32	2.4	0.030
40329 1YRM*	0.012	0.60	3.8
40334 1YRM*	-0.25	-1.4	1.9
40344 1YRM*	1.3	-2.1	-1.1
40370 1YRM	-0.55	-0.43	1.0
40382 1YRM*	-1.1	0.42	0.44
40384 1YRM*	-0.054	-0.84	-0.56
40405 1YRM*	0.18	0.95	0.35
40411 1YRM*	1.4	-0.56	0.14
40412 1YRM*	0.41	-0.88	-3.3
40428 1YRM*	-0.69	-0.82	1.0
40429 1YRM*	-0.59	-0.45	-0.19
40441 1YRM*	-1.0	0.036	0.058
40445 1YRM*	-0.82	0.99	0.93
40447 1YRM*	-2.6	-2.3	1.2
40449 1YRM*	0.29	-0.40	0.41
40451 1YRM*	0.60	-0.27	-0.72
40454 1YRM*	-0.91	0.38	1.6

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40456 1YRM*	0.71	0.33	-0.23
40458 1YRM*	0.66	-0.81	2.0
40459 1YRM	0.51	-0.17	0.87
40460 1YRM*	0.79	-0.34	1.6
40461 1YRM*	0.71	-0.43	-0.39
40464 1YRM*	0.93	-0.28	0.83
40465 1YRM*	-1.1	-0.34	-0.71
40466 1YRM*	-0.51	0.031	0.17
40467 1YRM*	-0.94	-0.96	0.48
40469 1YRM*	-0.019	0.26	0.43
40470 1YRM*	0.15	-0.21	0.58
40474 1YRM*	0.14	-0.55	2.3
40478 1YRM*	0.85	-0.093	0.096
40480 1YRM*	0.020	-0.49	0.12
40485 1YRM*	-0.51	1.6	0.66
40490 1YRM*	-1.3	0.32	0.82
40491 1YRM*	-0.71	-0.88	0.70
40492 1YRM*	-0.15	0.37	0.16
40499 1YRM*	-0.55	0.16	0.20
40500 1YRM*	0.19	-1.2	0.80
40502 1YRM	-0.16	-0.32	0.41

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40509 1YRM	0.81	1.4	0.35
40514 1YRM*	-0.52	0.11	0.44
40523 1YRM*	0.90	-0.50	-0.98
40525 1YRM*	1.4	-2.1	-0.81
40530 1YRM*	0.20	-1.2	0.64
40532 1YRM*	-2.3	-1.1	1.0
40541 1YRM*	1.7	-0.61	1.5
40543 1YRM*	-1.2	-1.8	0.21
40544 1YRM*	0.43	-1.1	0.049
40547 1YRM*	0.18	-0.75	1.2
40548 1YRM*	0.44	-0.15	0.33
40551 1YRM*	1.3	-0.34	-0.25
40552 1YRM*	-0.65	-0.088	0.20
40564 1YRM*	-1.6	-1.2	1.1
40568 1YRM*	1.8	-2.8	-0.60
40579 1YRM*	0.93	0.98	0.88
40581 1YRM	2.0	0.0021	1.4
40586 1YRM*	-3.2	-0.53	-0.25
40587 1YRM*	-0.47	-0.39	0.88
40589 1YRM*	-2.0	-0.031	-0.44
40594 1YRM*	-1.6	-0.87	1.7

Sample ID	PCA Factor Score		
	PC1	**PC2**	**PC3**
40602 1YRM*	-0.25	1.1	1.0
40605 1YRM*	1.9	-0.19	0.70
40607 1YRM*	0.52	-0.58	1.1
40611 1YRM*	0.72	-1.4	1.3
40614 1YRM*	0.99	-0.79	1.1
40616 1YRM*	-0.020	-0.25	0.33
40633 1YRM*	-0.41	-0.50	2.3
40646 1YRM*	-2.6	-1.5	1.0
40652 1YRM*	0.90	-0.48	1.6
40662 1YRM*	0.17	-0.61	-0.81
40670 1YRM*	-0.040	0.0086	-0.70
40719 1YRM*	-1.4	-0.18	1.8

Appendix H: Total n values for infant characteristics used to evaluate prenatal maternal plasma. Notes for columns are described at the bottom of the table.

	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
n value	51 (wheeze), 34 (control)	118 (female), 106 (male)	214	199	196	198	171 (vaginal), 49 (C-section)	222

Wheeze = Whether or not the infant had incidences of recurrent wheezing at one year of age (wheeze) or no wheezing (control)

Sex = Sex of the infant

Weight = Birth weight of infant

Length = Birth length of infant

Head = Head circumference

Ponderal = Pondera index of infant

Delivery = Delivery method (vaginal delivery or cesarean section (C-section))

Gestation = Gestational age

Appendix I: Infant characteristics for individual samples used to evaluate prenatal maternal plasma. Units and notes for columns are described at the bottom of the table.

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40074 PNM	NA	Female	3185	48.5	33.5	2.79	Vaginal	40.0
40091 PNM	NA	Male	4237	55.5	36.0	2.48	Vaginal	39.9
40110 PNM	Wheeze	Male	3978	52.0	34.0	2.83	C-section	38.0
40124 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40134 PNM	NA	Female	3976	53.5	35.0	2.60	Vaginal	40.4
40138 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40139 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40140 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40142 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40143 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40144 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40145 PNM	NA	Female	3105	51.0	33.5	2.34	Vaginal	41.3
40146 PNM	NA	Male	3555	49.5	36.0	2.93	C-section	40.7
40147 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40148 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40149 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40150 PNM	NA	Female	3750	54.0	34.5	2.38	Vaginal	41.1
40151 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40156 PNM	NA	Female	NA	NA	NA	NA	C-section	40.0
40157 PNM	Wheeze	Male	2745	49.5	31.0	2.26	NA	36.1
40158 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40159 PNM	Control	Male	3788	50.0	36.0	3.03	C-section	40.0
40160 PNM	NA	Female	3442	52.0	35.5	2.45	C-section	41.6
40161 PNM	NA	Male	3965	52.0	36.0	2.82	Vaginal	38.6

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40162 PNM	NA	Female	3560	53.5	35.0	2.32	C-section	40.0
40163 PNM	NA	Female	4516	52.5	36.0	3.12	Vaginal	39.6
40164 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40165 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40166 PNM	NA	Female	3408	51.0	35.0	2.57	Vaginal	39.0
40167 PNM	NA	Male	3693	49.5	34.5	3.04	Vaginal	39.0
40168 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40169 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40170 PNM	Control	Male	3511	51.0	32.0	2.65	Vaginal	38.0
40171 PNM	Wheeze	Female	3513	53.0	33.0	2.36	Vaginal	40.0
40172 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40173 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40175 PNM	Control	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40176 PNM	Wheeze	Female	3737	51.0	33.0	2.82	Vaginal	40.6
40177 PNM	NA	Female	2976	51.0	34.0	2.24	Vaginal	37.4
40178 PNM	NA	Male	3387	NA	NA	NA	Vaginal	38.4
40179 PNM	NA	Male	3700	50.0	33.0	2.96	Vaginal	40.1
40180 PNM	NA	Male	4309	55.0	37.5	2.59	C-section	41.7
40181 PNM	NA	Male	3297	NA	NA	NA	C-section	38.9
40185 PNM	NA	Male	4453	54.5	35.5	2.75	Vaginal	41.0
40186 PNM	NA	Male	3810	51.0	33.0	2.87	C-section	41.3
40187 PNM	Wheeze	Male	3725	53.0	35.0	2.50	Vaginal	39.9
40188 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40190 PNM	NA	Male	3289	53.3	49.0	2.17	Vaginal	39.7
40192 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40193 PNM	Wheeze	Male	4036	54.0	36.0	2.56	C-section	40.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40194 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40195 PNM	NA	Female	3333	51.0	35.0	2.51	C-section	38.7
40196 PNM	NA	Female	3806	52.0	35.5	2.71	Vaginal	41.0
40197 PNM	Control	Female	2406	49.5	32.5	1.98	Vaginal	39.0
40198 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40203 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40204 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40205 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40206 PNM	NA	Female	2889	53.0	34.0	1.94	Vaginal	39.0
40209 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40210 PNM	NA	Male	3490	53.0	34.5	2.34	Vaginal	39.0
40211 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40212 PNM	NA	Female	3875	57.0	35.5	2.09	C-section	40.9

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40213 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40215 PNM	NA	Female	2532	48.0	31.5	2.29	Vaginal	37.3
40218 PNM	Control	Female	3113	51.0	33.0	2.35	Vaginal	40.7
40224 PNM	NA	Female	4432	54.0	38.0	2.81	Vaginal	40.1
40225 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40226 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40227 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40228 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40232 PNM	NA	Male	3346	38.0	NA	NA	Vaginal	40.0
40235 PNM	NA	Male	3183	49.5	36.5	2.62	Vaginal	37.0
40241 PNM	NA	Female	2946	49.5	33.5	2.43	Vaginal	39.0
40243 PNM	NA	Female	3113	51.0	35.0	2.35	C-section	40.0
40244 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40245 PNM	NA	Male	2931	51.0	34.0	2.21	C-section	40.6
40246 PNM	Control	Female	NA	NA	NA	NA	C-section	37.0
40247 PNM	NA	Male	3376	52.0	33.0	2.40	Vaginal	39.3
40248 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40249 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40250 PNM	Control	Female	3035	48.5	33.5	2.66	C-section	38.1
40252 PNM	NA	Male	4289	54.5	36.5	2.65	Vaginal	41.3
40254 PNM	NA	Female	3869	51.0	33.5	2.92	Vaginal	39.7
40255 PNM	NA	Female	3921	56.0	34.5	2.23	Vaginal	39.6
40256 PNM	NA	Male	3304	49.0	34.0	2.81	Vaginal	37.1
40257 PNM	Wheeze	Male	2915	49.5	33.0	2.40	Vaginal	41.1
40258 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40259 PNM	NA	Female	4097	53.0	34.0	2.75	C-section	41.3

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40260 PNM	Control	Female	3054	49.5	33.0	2.52	Vaginal	42.0
40261 PNM	NA	Male	3505	51.0	36.5	2.64	C-section	40.4
40264 PNM	Wheeze	Female	3410	34.0	49.5	8.68	Vaginal	39.7
40265 PNM	NA	Female	2743	53.5	33.0	1.79	Vaginal	41.3
40268 PNM	NA	Male	4125	53.8	36.0	2.65	Vaginal	39.7
40269 PNM	Wheeze	Male	4246	49.6	37.0	3.48	C-section	38.9
40271 PNM	NA	Male	2476	NA	34.0	NA	C-section	35.4
40272 PNM	NA	Male	4769	58.0	38.0	2.44	Vaginal	41.0
40273 PNM	Control	Male	3772	52.0	35.0	2.68	Vaginal	40.1
40274 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40275 PNM	NA	Female	3863	53.0	35.5	2.59	Vaginal	40.9
40276 PNM	Wheeze	Female	3185	48.0	33.0	2.88	Vaginal	40.9
40279 PNM	NA	Male	2387	47.0	32.0	2.30	Vaginal	39.4

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40280 PNM	NA	Male	NA	NA	NA	NA	C-section	39.0
40284 PNM	Wheeze	Female	3753	51.0	35.0	2.83	Vaginal	39.3
40287 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40288 PNM	NA	Male	4232	52.0	37.0	3.01	C-section	39.0
40289 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40290 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40291 PNM	NA	Female	3560	NA	NA	NA	Vaginal	38.7
40295 PNM	Wheeze	Male	4046	53.5	36.0	2.64	Vaginal	40.6
40296 PNM	NA	Female	3863	51.0	36.0	2.91	Vaginal	38.1
40297 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40300 PNM	Control	Female	3495	51.0	35.0	2.63	Vaginal	41.7
40301 PNM	NA	Male	4125	56.0	36.5	2.35	C-section	38.0
40302 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40303 PNM	NA	Male	3866	52.0	36.5	2.75	C-section	41.4
40305 PNM	NA	Female	3562	NA	NA	NA	Vaginal	40.1
40306 PNM	NA	Male	3603	53.5	37.0	2.35	Vaginal	37.7
40311 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40312 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40313 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40315 PNM	NA	Female	3356	52.0	34.7	2.39	Vaginal	40.6
40316 PNM	NA	Male	3200	NA	NA	NA	Vaginal	39.0
40317 PNM	NA	Female	NA	NA	NA	NA	Vaginal	40.3
40318 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40319 PNM	Control	Male	4782	NA	NA	NA	C-section	41.6
40320 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40321 PNM	Wheeze	Male	3620	55.0	34.8	2.18	Vaginal	40.3

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40322 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40323 PNM	NA	Female	2855	50.0	34.0	2.28	Vaginal	40.1
40324 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40325 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40326 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40327 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40328 PNM	Wheeze	Female	2768	48.5	34.0	2.43	Vaginal	37.9
40329 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40330 PNM	NA	Female	3365	51.0	34.5	2.54	C-section	41.4
40331 PNM	Wheeze	Male	NA	NA	NA	NA	Vaginal	40.4
40332 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40333 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40334 PNM	NA	Male	4175	NA	NA	NA	NA	41.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40335 PNM	NA	Male	3263	51.0	35.0	2.46	Vaginal	38.1
40336 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40338 PNM	Control	Male	4610	56.0	37.0	2.63	Vaginal	40.9
40342 PNM	NA	Female	2895	50.5	33.5	2.25	NA	37.1
40343 PNM	NA	Male	4610	56.0	37.0	2.63	Vaginal	40.9
40344 PNM	Wheeze	Male	4521	NA	NA	NA	C-section	40.7
40345 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40346 PNM	NA	Female	3741	52.0	34.5	2.66	Vaginal	40.0
40347 PNM	NA	Female	3587	54.0	33.5	2.28	Vaginal	39.0
40349 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40350 PNM	NA	Female	3076	52.0	33.5	2.19	Vaginal	40.7
40352 PNM	Control	Female	3101	48.0	34.0	2.80	Vaginal	39.1
40353 PNM	NA	Female	3314	51.0	34.5	2.50	Vaginal	38.7

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40354 PNM	Control	Male	3670	53.5	33.0	2.40	Vaginal	37.3
40357 PNM	Control	Male	3763	53.0	36.5	2.53	Vaginal	41.9
40358 PNM	NA	Female	NA	NA	NA	NA	Vaginal	37.3
40359 PNM	NA	Male	4129	56.0	37.0	2.35	Vaginal	41.0
40360 PNM	NA	Male	3306	52.0	35.5	2.35	Vaginal	40.0
40361 PNM	NA	Female	3280	53.0	34.0	2.20	Vaginal	41.0
40362 PNM	NA	Female	3234	54.0	33.0	2.05	Vaginal	40.3
40364 PNM	NA	Female	3733	53.0	35.0	2.51	Vaginal	40.4
40365 PNM	NA	Female	3166	51.0	34.0	2.39	Vaginal	39.0
40366 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40369 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40371 PNM	NA	Female	3405	52.0	34.5	2.42	Vaginal	42.1
40372 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40375 PNM	NA	Female	3288	50.0	32.5	2.63	Vaginal	40.0
40376 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40378 PNM	NA	Female	3697	54.5	35.5	2.28	Vaginal	40.0
40379 PNM	NA	Female	3408	55.5	34.5	1.99	C-section	38.0
40381 PNM	Wheeze	Male	4199	51.0	34.5	3.17	Vaginal	38.6
40382 PNM	NA	Male	3656	51.5	35.5	2.68	Vaginal	41.1
40384 PNM	NA	Female	3040	46.0	33.0	3.12	Vaginal	38.4
40386 PNM	NA	Male	3496	49.5	37.0	2.88	C-section	38.6
40388 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40390 PNM	NA	Female	2960	NA	NA	NA	Vaginal	NA
40392 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40393 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40395 PNM	Wheeze	Female	3463	49.5	34.0	2.86	Vaginal	37.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40396 PNM	NA	Female	4521	56.0	34.5	2.57	Vaginal	41.6
40397 PNM	NA	Female	3483	NA	NA	NA	Vaginal	39.0
40399 PNM	NA	Male	3193	51.5	33.0	2.34	Vaginal	39.4
40401 PNM	Wheeze	Male	3771	51.0	37.0	2.84	Vaginal	39.3
40405 PNM	NA	Male	3036	52.0	33.5	2.16	Vaginal	42.0
40406 PNM	NA	Male	3299	49.5	36.0	2.72	Vaginal	40.9
40409 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40411 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40412 PNM	NA	Female	3402	50.0	33.0	2.72	Vaginal	39.1
40413 PNM	NA	Female	2897	49.0	33.0	2.46	C-section	38.7
40415 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40416 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40417 PNM	NA	Male	3077	49.5	34.5	2.54	C-section	38.6

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40418 PNM	NA	Female	3762	52.0	36.0	2.68	Vaginal	39.9
40419 PNM	NA	Male	NA	NA	NA	NA	Vaginal	39.7
40420 PNM	NA	Male	3679	52.0	35.5	2.62	Vaginal	39.0
40421 PNM	NA	Female	4342	56.0	36.5	2.47	Vaginal	41.7
40422 PNM	Wheeze	Female	3167	50.5	33.0	2.46	Vaginal	40.7
40424 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40425 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40428 PNM	Wheeze	Male	3369	52.0	33.0	2.40	Vaginal	38.9
40429 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40430 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40432 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40433 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40434 PNM	Wheeze	Female	3081	49.5	33.0	2.54	Vaginal	38.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40436 PNM	Control	Male	3840	53.0	37.0	2.58	Vaginal	38.0
40438 PNM	NA	Female	3252	50.0	34.0	2.60	Vaginal	40.0
40439 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40440 PNM	NA	Female	3037	51.0	33.5	2.29	Vaginal	41.7
40441 PNM	NA	Female	3509	50.0	33.0	2.81	Vaginal	40.4
40442 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40443 PNM	NA	Male	3848	54.5	35.0	2.38	Vaginal	37.9
40444 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40445 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40446 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40447 PNM	NA	Male	2725	43.5	33.0	3.31	Vaginal	37.0
40449 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40451 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40453 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40454 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40455 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40456 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40457 PNM	NA	Male	3803	53.0	34.5	2.55	Vaginal	39.3
40458 PNM	NA	Female	3876	51.5	33.5	2.84	Vaginal	40.0
40460 PNM	NA	Male	3223	49.5	35.0	2.66	Vaginal	39.1
40461 PNM	NA	Male	3360	52.0	36.0	2.39	C-section	39.7
40462 PNM	NA	Female	2779	NA	NA	NA	Vaginal	NA
40463 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40464 PNM	NA	Male	4046	56.0	38.0	2.30	Vaginal	41.1
40465 PNM	NA	Male	3626	57.0	NA	1.96	Vaginal	39.6
40466 PNM	Wheeze	Male	4141	50.0	36.0	3.31	Vaginal	40.6

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40467 PNM	NA	Male	3259	54.5	34.0	2.01	Vaginal	38.4
40468 PNM	Wheeze	Male	NA	NA	NA	NA	Vaginal	41.9
40469 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40470 PNM	NA	Male	3248	52.0	33.5	2.31	Vaginal	40.0
40471 PNM	NA	Male	3621	52.0	36.5	2.58	Vaginal	39.7
40472 PNM	NA	Female	3422	53.7	34.0	2.21	Vaginal	38.9
40474 PNM	Wheeze	Male	3080	46.5	32.5	3.06	C-section	38.7
40475 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40476 PNM	NA	Female	3410	51.0	NA	2.57	C-section	40.4
40478 PNM	NA	Male	4070	53.0	37.0	2.73	Vaginal	41.3
40480 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40481 PNM	Control	Male	3643	53.3	35.5	2.41	Vaginal	40.6
40482 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40483 PNM	Wheeze	Female	4179	56.0	36.0	2.38	Vaginal	41.7
40485 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40489 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40490 PNM	NA	Male	3588	52.0	35.5	2.55	C-section	38.0
40491 PNM	Wheeze	Female	3225	51.0	33.0	2.43	Vaginal	41.0
40492 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40494 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40495 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40496 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40497 PNM	NA	Female	3072	52.0	34.0	2.18	Vaginal	39.3
40498 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40499 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40500 PNM	NA	Female	4110	52.5	35.0	2.84	Vaginal	41.1

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40504 PNM	NA	Female	3969	49.5	35.8	3.27	C-section	38.3
40505 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40506 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40507 PNM	NA	Male	4209	52.0	36.0	2.99	Vaginal	39.4
40508 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40514 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40517 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40518 PNM	NA	Female	3506	53.0	34.0	2.35	Vaginal	40.1
40521 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40522 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40523 PNM	NA	Female	2736	49.5	33.0	2.26	C-section	39.0
40525 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40526 PNM	NA	Female	3789	51.0	35.0	2.86	C-section	39.4

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40527 PNM	NA	Male	3924	56.0	37.0	2.23	C-section	38.0
40528 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40529 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40530 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40532 PNM	NA	Male	3885	52.0	37.0	2.76	Vaginal	40.0
40533 PNM	NA	Male	3400	49.0	35.0	2.89	C-section	37.6
40535 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40537 PNM	NA	Male	3272	51.0	34.0	2.47	Vaginal	40.1
40538 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40539 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40541 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40542 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40543 PNM	NA	Female	3603	52.0	34.5	2.56	Vaginal	39.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40544 PNM	NA	Male	3549	52.2	34.5	2.50	Vaginal	40.6
40545 PNM	NA	Female	3336	49.5	34.0	2.75	Vaginal	38.3
40547 PNM	NA	Female	3032	49.0	35.5	2.58	C-section	39.0
40548 PNM	NA	Female	3779	NA	NA	NA	Vaginal	40.1
40549 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40551 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40552 PNM	NA	Female	NA	NA	NA	NA	C-section	41.0
40554 PNM	NA	Female	2847	47.5	33.5	2.66	C-section	37.0
40556 PNM	NA	Male	3542	53.5	36.0	2.31	Vaginal	40.0
40557 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40558 PNM	NA	Female	3432	51.0	34.0	2.59	Vaginal	38.9
40559 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40560 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40561 PNM	NA	Female	NA	NA	NA	NA	Vaginal	39.0
40563 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40564 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40566 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40568 PNM	NA	Male	3760	NA	NA	NA	C-section	38.3
40571 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40573 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40575 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40576 PNM	NA	Male	3358	51.5	34.0	2.46	Vaginal	38.9
40579 PNM	NA	Male	3376	49.5	35.0	2.78	Vaginal	41.1
40580 PNM	NA	Male	3995	53.0	37.0	2.68	Vaginal	38.7
40583 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40584 PNM	NA	Female	3104	49.0	33.5	2.64	C-section	40.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40586 PNM	NA	Female	2850	48.5	31.0	2.50	Vaginal	38.0
40587 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40588 PNM	NA	Male	4803	58.5	38.5	2.40	Vaginal	41.0
40589 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40590 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40592 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40593 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40594 PNM	NA	Female	3721	52.0	36.0	2.65	C-section	41.6
40600 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40602 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40603 PNM	NA	Male	4185	53.0	36.0	2.81	Vaginal	41.9
40604 PNM	NA	Female	3084	45.0	34.5	3.38	Vaginal	40.7
40605 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40607 PNM	NA	Female	2914	48.5	33.5	2.55	Vaginal	39.4
40611 PNM	Wheeze	Male	3389	51.0	34.5	2.55	Vaginal	39.0
40612 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40613 PNM	NA	Male	3696	52.0	36.0	2.63	Vaginal	41.3
40614 PNM	NA	Female	3422	50.5	34.5	2.66	Vaginal	41.4
40616 PNM	NA	Female	2760	47.0	32.5	2.66	Vaginal	38.3
40620 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40623 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40625 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40628 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40629 PNM	Control	Male	3406	51.0	35.0	2.57	Vaginal	39.0
40630 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40631 PNM	NA	Female	3338	56.0	32.0	1.90	Vaginal	42.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40632 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40633 PNM	NA	Female	3630	52.5	33.5	2.51	Vaginal	38.4
40644 PNM	NA	Female	2837	49.0	32.0	2.41	Vaginal	40.3
40646 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40647 PNM	NA	Male	3654	54.5	33.0	2.26	Vaginal	40.3
40648 PNM	NA	Female	3572	52.0	34.5	2.54	Vaginal	42.1
40649 PNM	NA	Male	3225	50.5	34.0	2.50	Vaginal	37.6
40650 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40651 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40652 PNM	Wheeze	Male	3621	54.0	34.5	2.30	Vaginal	39.6
40653 PNM	NA	Male	3618	NA	NA	NA	Vaginal	40.0
40654 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40656 PNM	NA	Female	3306	50.0	34.7	2.64	Vaginal	39.1

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40659 PNM	NA	Female	3183	48.5	35.5	2.79	Vaginal	40.0
40661 PNM	NA	Female	3326	49.0	34.5	2.83	Vaginal	37.6
40662 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40663 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40664 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40665 PNM	NA	Female	3153	50.5	33.0	2.45	C-section	36.1
40667 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40668 PNM	NA	Female	3080	51.5	32.0	2.25	Vaginal	39.4
40669 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40670 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40671 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40673 PNM	NA	Male	3500	52.0	36.0	2.49	Vaginal	39.0
40674 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40676 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40677 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40680 PNM	NA	Female	3100	47.5	34.0	2.89	Vaginal	39.0
40683 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40686 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40688 PNM	NA	Female	3327	51.0	35.5	2.51	Vaginal	42.0
40689 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40690 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40691 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40692 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40693 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40694 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40695 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40696 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40697 PNM	NA	Female	3327	55.0	33.5	2.00	Vaginal	39.4
40698 PNM	NA	Female	3720	51.0	33.0	2.80	C-section	41.9
40699 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40704 PNM	Wheeze	NA	NA	NA	NA	NA	NA	NA
40705 PNM	NA	Male	3203	50.0	34.5	2.56	Vaginal	38.3
40706 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40707 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40708 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40709 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40710 PNM	NA	Male	4170	59.3	34.3	2.00	Vaginal	40.3
40711 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40712 PNM	NA	Female	3431	54.5	34.0	2.12	Vaginal	41.0

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40713 PNM	NA	Female	3182	51.5	33.0	2.33	Vaginal	39.4
40718 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40719 PNM	NA	Male	2834	54.5	30.3	1.75	Vaginal	40.4
40720 PNM	NA	Female	3241	51.5	NA	2.37	C-section	41.4
40722 PNM	Control	NA	NA	NA	NA	NA	NA	NA
40723 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40724 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40725 PNM	Control	Male	3580	53.5	35.0	2.34	Vaginal	38.6
40726 PNM	NA	Female	2435	48.0	32.0	2.20	Vaginal	37.6
40727 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40730 PNM	NA	Male	3923	53.0	35.0	2.64	Vaginal	41.0
40731 PNM	NA	Female	4057	53.5	35.0	2.65	NA	40.7
40732 PNM	NA	Male	3384	49.5	34.0	2.79	Vaginal	38.7

Sample ID	Infant Characteristics							
	Wheeze	**Sex**	**Weight**	**Length**	**Head**	**Ponderal**	**Delivery**	**Gestation**
40739 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40740 PNM	Wheeze	Female	3377	51.5	32.0	2.47	Vaginal	40.7
40745 PNM	NA	Female	4077	56.0	34.0	2.32	Vaginal	41.0
40792 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40834 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40890 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40891 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40893 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40894 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40925 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40931 PNM	NA	NA	NA	NA	NA	NA	NA	NA
40955 PNM	NA	NA	NA	NA	NA	NA	NA	NA
41077 PNM	NA	NA	NA	NA	NA	NA	NA	NA

Wheeze = Whether or not the infant had incidences of recurrent wheezing at one year of age (wheeze) or no wheezing (control)

Sex = Sex of the infant

Weight = Birth weight of infant (grams)

Length = Birth length of infant (cm)

Head = Head circumference (cm)

Ponderal = Pondera index of infant (g/cm^3)

Delivery = Delivery method (vaginal delivery or cesarean section (C-section))

Gestation = Gestational age (weeks)

NA = not applicable due to missing surveys, missing survey questions, participant did not know answer to the question or not available from medical records.

Appendix J: Total n values for infant characteristics used to determine the modified asthma predictive index with prenatal plasma. Notes for columns are described at the bottom of the table.

	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
n value	51 (wheeze), 34 (control)	59 (no), 26 (yes)	52 (no), 6 (yes)	51 (no), 1 (yes)	47 (no), 5 (yes)	75 (no), 10 (yes)	4 (no), 3 (yes)	7 (no), 22 (yes)

Wheeze = Whether or not the infant had incidences of recurrent wheezing at one year of age (wheeze) or no wheezing (control)

Parental = Whether or not child had parental history of asthma

Dermatitis = Whether or not child had atopic dermatitis which was diagnosed by a physician

Aeroallergen = Whether or not child had allergic sensitization to at least one of the following aeroallergens: *A. tenuis*, cat hair, dog epithelium, *D. pteronyssinus*, *D. farinae*, German cockroach

Peanut = Whether or not child had allergic sensitization to milk, egg, or peanuts

No cold = Whether or not child had at least one wheezing episode without a cold

Eosiniphil = Whether or not child had eosiniphil level above 4%

Appendix K: Infant characteristics for individual samples used to determine the modified asthma predictive index using prenatal plasma. Notes for columns are described at the bottom of the table.

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40110 PNM	Wheeze	Yes	No	No	No	Yes	Yes	Yes
40147 PNM	Control	Yes	No	No	No	No	No	NA
40157 PNM	Wheeze	NA	No	No	No	No	NA	NA
40159 PNM	Control	No	No	No	No	No	No	No
40165 PNM	Wheeze	NA	NA	NA	NA	No	NA	NA
40170 PNM	Control	Yes	No	No	No	Yes	NA	NA
40171 PNM	Wheeze	Yes	No	No	No	No	No	Yes
40172 PNM	Wheeze	No	Yes	No	No	No	No	Yes
40175 PNM	Control	No	No	No	No	No	NA	No
40176 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40187 PNM	Wheeze	Yes	No	No	No	No	NA	Yes

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40188 PNM	Wheeze	Yes	No	No	No	No	Yes	Yes
40193 PNM	Wheeze	No	NA	No	No	No	NA	NA
40197 PNM	Control	No	No	No	No	No	NA	No
40203 PNM	Wheeze	No	No	No	No	No	NA	NA
40211 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40218 PNM	Control	No	No	No	No	No	NA	No
40227 PNM	Wheeze	NA	NA	NA	NA	No	NA	NA
40244 PNM	Wheeze	No	No	No	No	No	NA	NA
40246 PNM	Control	No	Yes	No	Yes	No	NA	NA
40250 PNM	Control	Yes	No	No	No	No	NA	NA
40257 PNM	Wheeze	NA	Yes	No	No	No	NA	Yes
40260 PNM	Control	No	No	No	No	No	NA	No
40264 PNM	Wheeze	No	No	No	Yes	No	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40269 PNM	Wheeze	No	No	No	No	Yes	NA	NA
40273 PNM	Control	No	No	No	No	No	NA	No
40274 PNM	Wheeze	NA	No	No	No	No	NA	NA
40276 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40284 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40287 PNM	Control	No	No	No	No	No	NA	No
40289 PNM	Wheeze	No	No	No	No	No	Yes	NA
40295 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40300 PNM	Control	Yes	NA	No	No	No	NA	NA
40319 PNM	Control	Yes	No	No	No	No	NA	NA
40320 PNM	Wheeze	No	No	Yes	No	No	NA	Yes
40321 PNM	Wheeze	NA	No	No	No	No	NA	NA
40324 PNM	Wheeze	No	No	No	No	No	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40328 PNM	Wheeze	Yes	Yes	No	Yes	No	NA	Yes
40331 PNM	Wheeze	Yes	No	No	Yes	Yes	NA	Yes
40336 PNM	Control	Yes	No	No	No	No	NA	NA
40338 PNM	Control	NA	NA	No	No	No	NA	NA
40344 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40352 PNM	Control	NA	NA	NA	NA	No	NA	NA
40354 PNM	Control	No	No	No	Yes	No	NA	NA
40357 PNM	Control	NA	No	NA	NA	No	NA	NA
40366 PNM	Wheeze	Yes	NA	No	No	No	NA	Yes
40372 PNM	Wheeze	No	NA	No	No	Yes	NA	NA
40381 PNM	Wheeze	Yes	No	No	No	No	NA	Yes
40388 PNM	Control	Yes	No	NA	NA	No	NA	NA
40395 PNM	Wheeze	Yes	No	No	No	Yes	NA	Yes

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40401 PNM	Wheeze	No	NA	No	No	No	NA	NA
40422 PNM	Wheeze	Yes	No	NA	NA	No	NA	Yes
40428 PNM	Wheeze	No	No	No	No	No	NA	NA
40434 PNM	Wheeze	No	NA	No	No	No	NA	NA
40436 PNM	Control	No	NA	NA	NA	No	NA	NA
40439 PNM	Control	No	NA	NA	NA	No	NA	NA
40442 PNM	Control	No	NA	NA	NA	No	NA	NA
40449 PNM	Wheeze	No	No	No	No	No	NA	NA
40453 PNM	Control	No	NA	NA	NA	No	NA	NA
40456 PNM	Wheeze	No	NA	No	No	No	NA	NA
40466 PNM	Wheeze	Yes	No	NA	NA	No	NA	Yes
40468 PNM	Wheeze	No	No	NA	NA	No	NA	NA
40474 PNM	Wheeze	No	NA	No	No	No	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40481 PNM	Control	No	NA	NA	NA	No	NA	NA
40483 PNM	Wheeze	No	No	NA	NA	Yes	NA	NA
40491 PNM	Wheeze	No	No	NA	NA	No	NA	NA
40496 PNM	Control	NA	NA	NA	NA	No	NA	NA
40535 PNM	Control	No	No	NA	NA	No	NA	NA
40539 PNM	Wheeze	Yes	Yes	NA	NA	No	NA	Yes
40551 PNM	Control	No	Yes	NA	NA	No	NA	NA
40587 PNM	Wheeze	No	NA	No	No	Yes	NA	NA
40602 PNM	Control	NA	No	NA	NA	No	NA	NA
40611 PNM	Wheeze	No	No	NA	NA	No	NA	NA
40629 PNM	Control	No	No	NA	NA	No	NA	NA
40652 PNM	Wheeze	NA	No	NA	NA	No	NA	NA
40662 PNM	Control	No	No	NA	NA	No	NA	NA

Sample ID	Infant Characteristics							
	Wheeze	**Parental**	**Dermatitis**	**Aeroallergen**	**Peanut**	**No cold**	**Eosinophil**	**Pos/Neg**
40663 PNM	Wheeze	NA	NA	NA	NA	No	NA	NA
40671 PNM	Wheeze	NA	NA	NA	NA	Yes	NA	NA
40691 PNM	Control	No	NA	NA	NA	No	NA	NA
40693 PNM	Wheeze	Yes	NA	NA	NA	Yes	NA	Yes
40704 PNM	Wheeze	NA	NA	NA	NA	No	NA	NA
40711 PNM	Control	NA	No	NA	NA	No	NA	NA
40722 PNM	Control	NA	NA	NA	NA	No	NA	NA
40725 PNM	Control	NA	NA	NA	NA	No	NA	NA
40740 PNM	Wheeze	NA	NA	NA	NA	No	NA	NA

Wheeze = Whether or not the infant had incidences of recurrent wheezing at one year of age (wheeze) or no wheezing (control)

Parental = Whether or not child had parental history of asthma

Dermatitis = Whether or not child had atopic dermatitis which was diagnosed by a physician

Aeroallergen = Whether or not child had allergic sensitization to at least one of the following aeroallergens: *A. tenuis*, cat hair, dog epithelium, *D. pteronyssinus*, *D. farinae*, German cockroach

Peanut = Whether or not child had allergic sensitization to milk, egg, or peanuts

No cold = Whether or not child had at least one wheezing episode without a cold

Eosiniphil = Whether or not child had eosiniphil level above 4%

NA = not applicable due to missing surveys, missing survey questions, participant did not know answer to the question or not available from medical records.

Appendix L: Total n values for prenatal maternal characteristics used to evaluate prenatal maternal plasma. Notes for columns are described at the bottom of the table.

	Maternal Characteristics				
	Age	**Deliveries**	**Diabetes**	**B.P.**	**Smoke**
n value	413	99 (0), 68 (1), 36 (2), 16 (3 or more)	280 (no), 8 (yes)	281 (no), 7 (yes)	272 (no), 15 (yes)

Age = Age of mother at time of blood draw

Deliveries = Number of babies delivered by mother written as n value (number of deliveries)

Diabetes = Whether or not mother had diabetes during pregnancy

B.P. = Whether or not mother had high blood pressure during pregnancy

Smoke = Whether or not mother smoked during pregnancy

Appendix M: Prenatal maternal characteristics for individual samples used to evaluate prenatal maternal plasma. Units and notes for columns are described at the bottom of the table.

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40074 PNM	32.3	2	No	No	No
40091 PNM	25.6	0	No	No	No
40110 PNM	38.6	2	No	No	No
40124 PNM	33.5	NA	No	No	No
40134 PNM	31.6	1	NA	NA	NA
40138 PNM	29.4	NA	No	No	No
40139 PNM	28.7	NA	No	No	No
40140 PNM	32.2	NA	No	No	No
40142 PNM	34.5	NA	No	No	No
40143 PNM	38.1	NA	No	No	No
40144 PNM	29.7	NA	No	No	No
40145 PNM	34.6	0	No	No	No
40146 PNM	39.3	0	No	No	No
40147 PNM	31.6	NA	No	No	No
40148 PNM	37.7	NA	No	No	No
40149 PNM	20.2	NA	No	No	Yes
40150 PNM	35.4	1	No	No	No
40151 PNM	32.9	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40156 PNM	31.6	1	NA	NA	NA
40157 PNM	23.2	0	NA	NA	NA
40158 PNM	28.8	NA	No	No	No
40159 PNM	32.8	0	No	No	No
40160 PNM	25.7	0	No	No	No
40161 PNM	26.8	0	No	No	No
40162 PNM	31.4	1	NA	NA	NA
40163 PNM	30.4	0	No	No	No
40164 PNM	30.3	NA	No	No	No
40165 PNM	25.5	NA	NA	NA	NA
40166 PNM	32.2	0	No	No	No
40167 PNM	28.9	1	NA	NA	NA
40168 PNM	19.4	NA	NA	NA	NA
40169 PNM	35.0	NA	No	No	No
40170 PNM	22.9	1	No	No	No
40171 PNM	31.1	0	No	No	No
40172 PNM	27.5	NA	No	No	No
40173 PNM	36.3	NA	No	No	No
40175 PNM	33.8	NA	No	No	No
40176 PNM	34.2	1	No	No	No
40177 PNM	40.2	1	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40178 PNM	32.4	1	No	No	No
40179 PNM	27.6	0	NA	NA	NA
40180 PNM	30.7	0	No	No	Yes
40181 PNM	29.1	0	No	No	No
40185 PNM	29.4	0	No	No	No
40186 PNM	36.3	2	No	No	No
40187 PNM	37.7	0	No	No	No
40188 PNM	38.2	NA	Yes	No	No
40190 PNM	29.4	1	No	No	No
40192 PNM	34.9	NA	No	No	No
40193 PNM	21.1	0	No	No	No
40194 PNM	31.2	NA	No	No	No
40195 PNM	33.4	2	No	No	No
40196 PNM	31.4	0	No	No	No
40197 PNM	27.2	0	No	No	No
40198 PNM	31.7	NA	No	No	No
40203 PNM	34.5	NA	No	No	No
40204 PNM	32.2	NA	No	No	No
40205 PNM	32.4	NA	No	No	No
40206 PNM	31.5	0	No	No	No
40209 PNM	34.6	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40210 PNM	26.1	1	No	No	No
40211 PNM	34.1	NA	No	No	No
40212 PNM	36.4	0	No	No	No
40213 PNM	28.9	NA	No	No	No
40215 PNM	38.7	0	NA	NA	NA
40218 PNM	32.0	0	No	No	No
40224 PNM	35.3	4	No	No	No
40225 PNM	29.1	NA	No	No	Yes
40226 PNM	30.5	NA	No	No	No
40227 PNM	19.5	NA	NA	NA	NA
40228 PNM	24.3	NA	No	No	No
40232 PNM	31.0	1	No	No	No
40235 PNM	28.0	0	No	No	No
40241 PNM	33.7	2	No	No	No
40243 PNM	33.5	1	NA	NA	NA
40244 PNM	27.6	NA	No	No	No
40245 PNM	34.6	1	No	No	No
40246 PNM	31.1	0	No	No	No
40247 PNM	35.1	2	No	No	No
40248 PNM	33.1	NA	NA	NA	NA
40249 PNM	34.4	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40250 PNM	33.1	1	No	No	No
40252 PNM	33.8	5	NA	NA	NA
40254 PNM	34.3	1	No	No	No
40255 PNM	36.4	2	No	No	No
40256 PNM	26.6	1	No	No	No
40257 PNM	27.0	1	NA	NA	NA
40258 PNM	34.8	NA	No	No	No
40259 PNM	29.2	0	No	No	No
40260 PNM	27.2	0	No	Yes	No
40261 PNM	32.7	0	No	No	No
40264 PNM	34.1	1	No	No	No
40265 PNM	38.2	0	No	No	No
40268 PNM	32.5	NA	NA	NA	NA
40269 PNM	29.0	0	No	Yes	No
40271 PNM	26.1	0	NA	NA	NA
40272 PNM	31.7	1	No	No	No
40273 PNM	30.0	1	No	No	No
40274 PNM	33.0	NA	NA	NA	NA
40275 PNM	26.8	1	No	No	No
40276 PNM	28.7	1	No	No	No
40279 PNM	24.1	0	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40280 PNM	31.7	1	No	No	No
40284 PNM	33.1	2	No	No	No
40287 PNM	27.0	NA	Yes	No	No
40288 PNM	39.2	1	No	No	No
40289 PNM	39.9	NA	No	No	Yes
40290 PNM	31.1	NA	No	No	No
40291 PNM	29.1	2	No	No	No
40295 PNM	33.6	1	No	No	No
40296 PNM	33.2	1	No	No	No
40297 PNM	29.4	NA	No	No	No
40300 PNM	33.6	0	No	No	No
40301 PNM	22.5	0	NA	NA	NA
40302 PNM	21.0	NA	No	No	No
40303 PNM	31.6	0	NA	NA	NA
40305 PNM	23.5	0	No	No	No
40306 PNM	30.1	1	NA	NA	NA
40311 PNM	32.0	NA	No	No	No
40312 PNM	36.7	NA	No	No	No
40313 PNM	23.1	NA	NA	NA	NA
40315 PNM	35.0	1	No	No	No
40316 PNM	38.6	2	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40317 PNM	33.0	2	No	No	No
40318 PNM	32.7	NA	No	No	No
40319 PNM	29.4	0	No	No	No
40320 PNM	29.4	NA	No	No	No
40321 PNM	28.8	1	NA	NA	NA
40322 PNM	25.0	NA	No	No	No
40323 PNM	31.8	2	No	No	No
40324 PNM	32.9	NA	No	No	No
40325 PNM	30.7	NA	No	No	No
40326 PNM	30.7	NA	No	No	No
40327 PNM	32.2	NA	No	No	Yes
40328 PNM	31.2	4	NA	NA	NA
40329 PNM	34.9	NA	No	No	No
40330 PNM	35.1	0	No	No	No
40331 PNM	36.5	4	No	No	No
40332 PNM	36.9	NA	NA	NA	NA
40333 PNM	32.9	NA	NA	NA	NA
40334 PNM	28.5	0	No	No	No
40335 PNM	35.0	1	No	No	No
40336 PNM	27.0	NA	No	No	Yes
40338 PNM	29.5	2	NA	NA	NA

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40342 PNM	35.4	3	No	Yes	No
40343 PNM	37.5	2	No	No	No
40344 PNM	20.5	0	No	No	Yes
40345 PNM	29.8	NA	No	No	No
40346 PNM	29.3	2	No	No	No
40347 PNM	32.1	0	No	No	No
40349 PNM	34.7	NA	No	No	Yes
40350 PNM	33.8	0	No	No	No
40352 PNM	18.9	3	NA	NA	NA
40353 PNM	22.0	1	NA	NA	NA
40354 PNM	26.2	0	Yes	No	No
40357 PNM	31.4	1	NA	NA	NA
40358 PNM	29.5	2	NA	NA	NA
40359 PNM	23.5	0	No	No	No
40360 PNM	29.5	1	No	No	No
40361 PNM	34.4	1	No	No	No
40362 PNM	25.0	NA	NA	NA	NA
40364 PNM	33.4	3	No	No	No
40365 PNM	36.2	1	No	No	No
40366 PNM	31.0	NA	No	No	No
40369 PNM	38.4	NA	No	No	Yes

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40371 PNM	27.2	0	No	No	No
40372 PNM	30.7	NA	No	No	NA
40375 PNM	35.3	2	No	No	No
40376 PNM	26.2	NA	No	No	No
40378 PNM	33.0	2	No	No	No
40379 PNM	28.5	2	No	No	No
40381 PNM	36.1	3	No	No	No
40382 PNM	30.9	0	No	No	No
40384 PNM	34.0	1	No	No	No
40386 PNM	31.3	0	No	No	No
40388 PNM	29.3	NA	No	No	No
40390 PNM	29.9	0	No	No	No
40392 PNM	32.3	NA	No	No	No
40393 PNM	29.3	NA	No	No	No
40395 PNM	25.7	1	NA	NA	NA
40396 PNM	33.2	0	No	No	No
40397 PNM	32.5	2	No	No	No
40399 PNM	25.0	1	No	No	No
40401 PNM	31.4	1	No	No	Yes
40405 PNM	29.5	2	NA	NA	NA
40406 PNM	30.7	0	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40409 PNM	28.2	NA	No	Yes	No
40411 PNM	37.0	NA	NA	NA	NA
40412 PNM	24.3	2	No	No	No
40413 PNM	29.8	2	NA	NA	NA
40415 PNM	23.0	NA	No	No	No
40416 PNM	23.5	NA	NA	NA	NA
40417 PNM	29.2	0	No	No	No
40418 PNM	37.4	3	No	No	No
40419 PNM	29.5	1	No	No	No
40420 PNM	25.8	1	No	No	No
40421 PNM	30.1	0	No	No	No
40422 PNM	28.1	0	No	No	No
40424 PNM	36.5	NA	NA	NA	NA
40425 PNM	35.1	NA	NA	NA	NA
40428 PNM	29.3	1	No	No	No
40429 PNM	30.7	NA	No	Yes	No
40430 PNM	36.1	NA	No	No	No
40432 PNM	28.6	NA	NA	NA	NA
40433 PNM	29.0	NA	NA	NA	NA
40434 PNM	28.1	1	No	No	No
40436 PNM	30.1	0	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40438 PNM	30.0	2	NA	NA	NA
40439 PNM	38.0	NA	Yes	No	No
40440 PNM	33.3	2	No	No	No
40441 PNM	20.7	0	No	No	No
40442 PNM	41.2	NA	No	No	No
40443 PNM	23.8	0	No	No	Yes
40444 PNM	32.8	NA	NA	NA	NA
40445 PNM	30.6	NA	No	No	Yes
40446 PNM	23.6	NA	No	No	No
40447 PNM	32.4	0	Yes	No	No
40449 PNM	25.0	NA	No	Yes	No
40451 PNM	23.4	NA	No	No	No
40453 PNM	37.2	NA	No	No	No
40454 PNM	35.3	NA	No	No	No
40455 PNM	31.2	NA	No	No	No
40456 PNM	32.2	NA	No	No	No
40457 PNM	27.1	1	No	No	No
40458 PNM	24.1	1	No	No	Yes
40460 PNM	31.2	1	NA	NA	NA
40461 PNM	26.3	0	No	No	No
40462 PNM	30.7	0	Yes	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40463 PNM	30.3	NA	No	No	No
40464 PNM	33.3	0	No	No	No
40465 PNM	31.4	0	No	No	No
40466 PNM	23.7	0	No	No	No
40467 PNM	30.4	2	No	No	No
40468 PNM	33.5	1	No	No	No
40469 PNM	27.2	NA	NA	NA	NA
40470 PNM	21.9	1	NA	NA	NA
40471 PNM	34.2	2	No	No	No
40472 PNM	27.1	1	No	No	No
40474 PNM	30.8	3	No	No	Yes
40475 PNM	32.3	NA	No	No	No
40476 PNM	29.7	0	No	No	No
40478 PNM	30.4	1	No	No	No
40480 PNM	28.9	NA	No	No	No
40481 PNM	23.9	0	No	No	No
40482 PNM	30.1	NA	No	No	No
40483 PNM	36.8	0	No	No	No
40485 PNM	32.9	NA	NA	NA	NA
40489 PNM	32.0	NA	NA	NA	NA
40490 PNM	31.6	2	NA	NA	NA

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40491 PNM	28.4	0	NA	NA	NA
40492 PNM	26.7	NA	NA	NA	NA
40494 PNM	30.7	NA	No	No	Yes
40495 PNM	31.5	NA	NA	NA	NA
40496 PNM	30.7	NA	NA	NA	NA
40497 PNM	29.7	3	NA	NA	NA
40498 PNM	26.7	NA	NA	NA	NA
40499 PNM	25.0	NA	NA	NA	NA
40500 PNM	24.9	0	No	No	No
40504 PNM	30.6	1	NA	NA	NA
40505 PNM	31.8	NA	No	No	No
40506 PNM	27.0	NA	No	No	No
40507 PNM	24.3	0	NA	NA	NA
40508 PNM	32.3	NA	No	No	No
40514 PNM	22.2	NA	No	No	No
40517 PNM	23.0	NA	No	No	No
40518 PNM	22.2	0	NA	NA	NA
40521 PNM	27.4	NA	No	No	No
40522 PNM	25.1	NA	NA	NA	NA
40523 PNM	26.9	0	No	No	No
40525 PNM	29.8	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40526 PNM	26.0	2	No	No	No
40527 PNM	26.1	1	No	No	No
40528 PNM	29.4	NA	NA	NA	NA
40529 PNM	30.3	NA	NA	NA	NA
40530 PNM	31.0	NA	No	No	No
40532 PNM	27.4	3	NA	NA	NA
40533 PNM	37.3	NA	Yes	No	No
40535 PNM	28.0	NA	No	No	No
40537 PNM	25.4	3	NA	NA	NA
40538 PNM	32.2	NA	NA	NA	NA
40539 PNM	24.7	NA	No	No	No
40541 PNM	28.7	NA	NA	NA	NA
40542 PNM	23.5	NA	No	No	No
40543 PNM	29.9	1	No	No	No
40544 PNM	36.3	1	No	No	No
40545 PNM	31.6	1	No	No	No
40547 PNM	33.9	1	No	No	No
40548 PNM	34.1	0	No	No	No
40549 PNM	31.3	NA	NA	NA	NA
40551 PNM	30.3	NA	No	No	No
40552 PNM	31.0	0	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40554 PNM	29.0	1	NA	NA	NA
40556 PNM	25.5	1	No	No	No
40557 PNM	22.6	NA	No	No	No
40558 PNM	28.1	0	No	No	No
40559 PNM	27.3	NA	No	No	No
40560 PNM	29.3	NA	No	No	No
40561 PNM	30.0	1	No	No	No
40563 PNM	23.4	NA	NA	NA	NA
40564 PNM	26.5	NA	No	No	No
40566 PNM	27.4	NA	NA	NA	NA
40568 PNM	26.1	0	No	No	No
40571 PNM	27.9	NA	No	No	No
40573 PNM	25.6	NA	No	No	No
40575 PNM	30.0	NA	No	No	No
40576 PNM	35.7	0	No	No	No
40579 PNM	36.8	0	NA	NA	NA
40580 PNM	36.2	3	No	No	No
40583 PNM	23.1	NA	No	No	No
40584 PNM	34.7	0	No	No	No
40586 PNM	31.7	1	NA	NA	NA
40587 PNM	34.4	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40588 PNM	35.4	2	No	No	No
40589 PNM	32.0	NA	No	No	No
40590 PNM	34.4	NA	NA	NA	NA
40592 PNM	34.3	NA	NA	NA	NA
40593 PNM	37.3	NA	NA	NA	NA
40594 PNM	24.5	0	No	No	No
40600 PNM	19.6	NA	No	No	No
40602 PNM	26.5	NA	NA	NA	NA
40603 PNM	33.7	2	NA	NA	NA
40604 PNM	33.2	0	NA	NA	NA
40605 PNM	31.0	NA	No	No	No
40607 PNM	21.6	0	No	No	No
40611 PNM	31.7	1	No	No	No
40612 PNM	23.8	NA	NA	NA	NA
40613 PNM	31.3	NA	No	No	No
40614 PNM	27.2	0	No	No	No
40616 PNM	30.5	0	No	No	No
40620 PNM	28.9	NA	NA	NA	NA
40623 PNM	28.3	NA	NA	NA	NA
40625 PNM	34.7	NA	No	No	No
40628 PNM	32.1	NA	NA	NA	NA

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40629 PNM	29.2	1	No	No	No
40630 PNM	19.4	NA	No	No	No
40631 PNM	28.6	0	No	No	No
40632 PNM	27.1	NA	No	No	No
40633 PNM	31.1	0	NA	NA	NA
40644 PNM	24.7	0	No	No	No
40646 PNM	41.2	NA	Yes	No	No
40647 PNM	37.5	0	No	No	No
40648 PNM	32.7	0	No	No	No
40649 PNM	30.4	0	No	No	No
40650 PNM	34.4	NA	NA	NA	NA
40651 PNM	31.7	NA	No	No	No
40652 PNM	39.1	2	NA	NA	NA
40653 PNM	25.4	0	No	No	No
40654 PNM	32.5	NA	NA	NA	NA
40656 PNM	24.4	0	No	No	No
40659 PNM	18.2	0	NA	NA	NA
40661 PNM	31.0	0	NA	NA	NA
40662 PNM	31.4	NA	No	No	No
40663 PNM	33.6	NA	NA	NA	NA
40664 PNM	35.0	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40665 PNM	36.0	0	NA	NA	NA
40667 PNM	27.4	NA	NA	NA	NA
40668 PNM	21.1	0	NA	NA	NA
40669 PNM	22.5	NA	NA	NA	NA
40670 PNM	42.6	NA	No	No	No
40671 PNM	19.0	NA	NA	NA	NA
40673 PNM	30.3	2	NA	NA	NA
40674 PNM	29.2	NA	No	No	No
40676 PNM	30.0	NA	No	No	No
40677 PNM	20.0	NA	No	No	No
40680 PNM	30.7	0	NA	NA	NA
40683 PNM	25.6	NA	No	No	No
40686 PNM	34.6	NA	NA	NA	NA
40688 PNM	32.5	1	NA	NA	NA
40689 PNM	36.6	NA	NA	NA	NA
40690 PNM	31.2	NA	NA	NA	NA
40691 PNM	28.9	NA	No	No	No
40692 PNM	36.1	NA	No	No	No
40693 PNM	26.2	NA	No	No	No
40694 PNM	32.5	NA	No	No	No
40695 PNM	30.0	NA	No	No	No

Sample ID	Maternal Characteristics				
	Age	Deliveries	Diabetes	B.P.	Smoke
40696 PNM	39.6	NA	No	No	No
40697 PNM	36.9	8	No	No	No
40698 PNM	27.3	0	NA	NA	NA
40699 PNM	27.1	NA	NA	NA	NA
40704 PNM	32.5	NA	NA	NA	NA
40705 PNM	33.8	2	No	No	No
40706 PNM	24.0	NA	NA	NA	NA
40707 PNM	24.2	NA	No	Yes	No
40708 PNM	NA	NA	NA	NA	NA
40709 PNM	21.0	NA	No	No	No
40710 PNM	31.4	1	No	No	No
40711 PNM	33.5	NA	NA	NA	NA
40712 PNM	31.4	1	No	No	No
40713 PNM	27.4	1	NA	NA	NA
40718 PNM	29.7	NA	NA	NA	NA
40719 PNM	33.8	0	NA	NA	NA
40720 PNM	30.9	NA	No	No	No
40722 PNM	32.2	NA	NA	NA	NA
40723 PNM	26.2	NA	No	No	No
40724 PNM	39.7	NA	NA	NA	NA
40725 PNM	26.2	0	NA	NA	NA

Sample ID	Maternal Characteristics				
	Age	**Deliveries**	**Diabetes**	**B.P.**	**Smoke**
40726 PNM	30.4	0	No	No	No
40727 PNM	28.7	NA	NA	NA	NA
40730 PNM	31.5	1	No	No	No
40731 PNM	33.2	2	NA	NA	NA
40732 PNM	42.9	3	NA	NA	NA
40739 PNM	24.4	NA	No	No	No
40740 PNM	27.9	0	NA	NA	NA
40745 PNM	34.4	2	NA	NA	NA
40792 PNM	29.4	NA	NA	NA	NA
40834 PNM	31.1	NA	NA	NA	NA
40890 PNM	30.8	NA	NA	NA	NA
40891 PNM	23.0	NA	NA	NA	NA
40893 PNM	28.9	NA	NA	NA	NA
40894 PNM	33.6	NA	NA	NA	NA
40925 PNM	23.4	NA	NA	NA	NA
40931 PNM	33.2	NA	NA	NA	NA
40955 PNM	25.2	NA	NA	NA	NA
41077 PNM	35.7	NA	NA	NA	NA

Age = Age of mother at time of blood draw (years)

Deliveries = Number of babies delivered by mother

Diabetes = Whether or not mother had diabetes during pregnancy

B.P. = Whether or not mother had high blood pressure during pregnancy

Smoke = Whether or not mother smoked during pregnancy

NA = not applicable due to missing surveys, missing survey questions, participant did not know answer to the question or not available from medical records.

Appendix N: Total n values for home characteristics used to evaluate prenatal maternal plasma. Notes for columns are described at the bottom of the table.

	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
n value	56 (1939 or earlier), 18 (1940-1949), 30 (1950-1959), 22 (1960-1969), 43 (1970-1979), 20 (1980-1989), 50 (1990 or later)	96 (0%), 29 (20%), 31 (40%), 11 (60%), 13 (80%), 119 (100%)	66 (no), 195 (yes)	20 (no), 23 (yes)

Home Built = When the participants home was built

Percent Carpet = Percentage of carpet in participants' most used room in their home

Renovations = Whether or not participants' did home renovations in the previous 12 months

Furniture = Whether or not participants' brought new furniture into their home in the previous six months

Appendix O: Home characteristics for individual samples used to evaluate prenatal maternal plasma. Units and notes for columns are described at the bottom of the table.

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40074 PNM	NA	40	NA	NA
40091 PNM	1939 or earlier	0	No	NA
40110 PNM	1990 or later	0	Yes	NA
40124 PNM	1990 or later	100	No	NA
40134 PNM	1970-1979	40	Yes	NA
40138 PNM	1990 or later	0	Yes	NA
40139 PNM	1950-1959	0	Yes	NA
40140 PNM	1970-1979	40	Yes	NA
40142 PNM	1939 or earlier	100	Yes	NA
40143 PNM	1990 or later	100	No	NA
40144 PNM	1990 or later	100	No	Yes
40145 PNM	1990 or later	0	No	NA
40146 PNM	1940-1949	40	Yes	NA
40147 PNM	NA	0	No	NA
40148 PNM	1980-1989	NA	Yes	NA
40149 PNM	NA	40	Yes	NA
40150 PNM	1940-1949	0	Yes	NA
40151 PNM	NA	100	Yes	No
40156 PNM	NA	100	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40157 PNM	NA	NA	NA	NA
40158 PNM	1990 or later	100	Yes	NA
40159 PNM	1980-1989	100	No	NA
40160 PNM	NA	100	No	Yes
40161 PNM	1960-1969	0	Yes	NA
40162 PNM	NA	40	NA	NA
40163 PNM	1970-1979	40	Yes	NA
40164 PNM	1940-1949	20	No	NA
40165 PNM	NA	NA	NA	NA
40166 PNM	1950-1959	0	Yes	NA
40167 PNM	NA	NA	NA	NA
40168 PNM	NA	NA	NA	NA
40169 PNM	1960-1969	NA	Yes	No
40170 PNM	1960-1969	100	No	NA
40171 PNM	1960-1969	0	Yes	NA
40172 PNM	1970-1979	0	Yes	NA
40173 PNM	1990 or later	100	Yes	NA
40175 PNM	1950-1959	40	Yes	NA
40176 PNM	1939 or earlier	40	No	NA
40177 PNM	1960-1969	0	Yes	NA
40178 PNM	1960-1969	20	No	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40179 PNM	NA	0	NA	NA
40180 PNM	1950-1959	20	No	NA
40181 PNM	1940-1949	40	Yes	NA
40185 PNM	1950-1959	0	Yes	NA
40186 PNM	1980-1989	100	Yes	NA
40187 PNM	1940-1949	NA	No	No
40188 PNM	1970-1979	100	No	NA
40190 PNM	1950-1959	60	No	NA
40192 PNM	1980-1989	Na	Yes	NA
40193 PNM	NA	100	No	NA
40194 PNM	1939 or earlier	NA	Yes	NA
40195 PNM	1940-1949	0	No	NA
40196 PNM	1970-1979	0	Yes	NA
40197 PNM	1960-1969	0	Yes	NA
40198 PNM	1939 or earlier	0	No	NA
40203 PNM	1950-1959	0	Yes	NA
40204 PNM	NA	0	Yes	NA
40205 PNM	1950-1959	20	Yes	NA
40206 PNM	1970-1979	40	No	NA
40209 PNM	1950-1959	100	Yes	No
40210 PNM	1970-1979	100	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40211 PNM	1950-1959	NA	No	NA
40212 PNM	1980-1989	100	Yes	Yes
40213 PNM	1980-1989	100	Yes	Yes
40215 PNM	NA	0	NA	NA
40218 PNM	1970-1979	0	Yes	NA
40224 PNM	1939 or earlier	80	Yes	NA
40225 PNM	1970-1979	0	Yes	NA
40226 PNM	1939 or earlier	60	Yes	NA
40227 PNM	NA	Na	NA	NA
40228 PNM	1980-1989	0	Yes	NA
40232 PNM	1939 or earlier	NA	Yes	NA
40235 PNM	1939 or earlier	0	Yes	NA
40241 PNM	1990 or later	0	No	NA
40243 PNM	NA	100	NA	NA
40244 PNM	1980-1989	0	Yes	NA
40245 PNM	1970-1979	20	Yes	Yes
40246 PNM	1990 or later	100	No	NA
40247 PNM	1960-1969	40	Yes	No
40248 PNM	NA	NA	NA	NA
40249 PNM	1950-1959	NA	Yes	NA
40250 PNM	1950-1959	0	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40252 PNM	NA	80	NA	NA
40254 PNM	1960-1969	40	Yes	NA
40255 PNM	1980-1989	100	Yes	NA
40256 PNM	1970-1979	100	Yes	NA
40257 PNM	NA	80	NA	NA
40258 PNM	1970-1979	0	Yes	NA
40259 PNM	1970-1979	100	Yes	NA
40260 PNM	NA	100	NA	NA
40261 PNM	1990 or later	100	No	NA
40264 PNM	NA	0	NA	Yes
40265 PNM	1960-1969	100	No	NA
40268 PNM	NA	0	NA	NA
40269 PNM	1980-1989	NA	Yes	NA
40271 PNM	NA	100	NA	NA
40272 PNM	1970-1979	80	Yes	NA
40273 PNM	1950-1959	100	Yes	Yes
40274 PNM	NA	80	NA	NA
40275 PNM	NA	40	NA	NA
40276 PNM	1939 or earlier	100	Yes	No
40279 PNM	1970-1979	0	NA	NA
40280 PNM	1940-1949	100	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40284 PNM	1939 or earlier	40	Yes	NA
40287 PNM	1970-1979	NA	No	NA
40288 PNM	1990 or later	20	Yes	NA
40289 PNM	NA	20	No	No
40290 PNM	1950-1959	40	Yes	NA
40291 PNM	1960-1969	0	Yes	NA
40295 PNM	1970-1979	0	Yes	NA
40296 PNM	1939 or earlier	0	Yes	NA
40297 PNM	1939 or earlier	0	Yes	No
40300 PNM	1990 or later	0	Yes	NA
40301 PNM	NA	NA	NA	NA
40302 PNM	NA	20	Yes	NA
40303 PNM	NA	NA	NA	NA
40305 PNM	1939 or earlier	100	NA	NA
40306 PNM	NA	0	NA	NA
40311 PNM	1970-1979	100	No	NA
40312 PNM	1990 or later	20	No	NA
40313 PNM	NA	100	NA	NA
40315 PNM	1960-1969	NA	No	NA
40316 PNM	1939 or earlier	0	Yes	NA
40317 PNM	1970-1979	0	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40318 PNM	1939 or earlier	0	Yes	NA
40319 PNM	1950-1959	100	NA	NA
40320 PNM	1970-1979	NA	No	NA
40321 PNM	NA	0	NA	NA
40322 PNM	1939 or earlier	100	Yes	NA
40323 PNM	1960-1969	0	No	NA
40324 PNM	1939 or earlier	100	Yes	NA
40325 PNM	1980-1989	100	Yes	NA
40326 PNM	1939 or earlier	100	No	No
40327 PNM	1970-1979	100	Yes	NA
40328 PNM	NA	0	NA	NA
40329 PNM	NA	100	NA	Yes
40330 PNM	1950-1959	0	Yes	Yes
40331 PNM	1970-1979	0	Yes	NA
40332 PNM	NA	NA	NA	NA
40333 PNM	NA	100	NA	NA
40334 PNM	1939 or earlier	20	Yes	NA
40335 PNM	1980-1989	20	Yes	Yes
40336 PNM	1960-1969	100	Yes	NA
40338 PNM	NA	100	NA	NA
40342 PNM	1990 or later	100	No	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40343 PNM	1939 or earlier	100	Yes	NA
40344 PNM	NA	NA	NA	NA
40345 PNM	1940-1949	20	NA	NA
40346 PNM	1939 or earlier	0	Yes	NA
40347 PNM	1970-1979	40	Yes	NA
40349 PNM	NA	100	NA	NA
40350 PNM	1939 or earlier	0	Yes	NA
40352 PNM	NA	NA	NA	NA
40353 PNM	NA	100	NA	NA
40354 PNM	1990 or later	100	No	NA
40357 PNM	NA	0	NA	NA
40358 PNM	NA	NA	NA	NA
40359 PNM	NA	100	Yes	NA
40360 PNM	1990 or later	0	Yes	Yes
40361 PNM	NA	100	NA	NA
40362 PNM	NA	NA	NA	NA
40364 PNM	1939 or earlier	40	No	NA
40365 PNM	1990 or later	40	Yes	NA
40366 PNM	1939 or earlier	100	No	No
40369 PNM	1939 or earlier	80	Yes	NA
40371 PNM	1939 or earlier	0	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40372 PNM	1940-1949	100	Yes	NA
40375 PNM	1990 or later	100	Yes	NA
40376 PNM	1990 or later	100	Yes	NA
40378 PNM	1990 or later	40	Yes	NA
40379 PNM	1950-1959	0	Yes	Yes
40381 PNM	1970-1979	0	Yes	NA
40382 PNM	1960-1969	0	Yes	NA
40384 PNM	1980-1989	100	Yes	NA
40386 PNM	1940-1949	0	Yes	NA
40388 PNM	1939 or earlier	0	Yes	NA
40390 PNM	1950-1959	100	No	NA
40392 PNM	NA	100	NA	NA
40393 PNM	1940-1949	0	Yes	Yes
40395 PNM	NA	NA	NA	NA
40396 PNM	1939 or earlier	0	No	NA
40397 PNM	1950-1959	100	No	NA
40399 PNM	1939 or earlier	20	Yes	NA
40401 PNM	1950-1959	20	Yes	NA
40405 PNM	NA	100	NA	NA
40406 PNM	1939 or earlier	100	Yes	NA
40409 PNM	1990 or later	100	No	No

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40411 PNM	NA	NA	NA	NA
40412 PNM	NA	60	No	No
40413 PNM	NA	0	NA	NA
40415 PNM	1960-1969	100	Yes	NA
40416 PNM	NA	NA	NA	NA
40417 PNM	1950-1959	100	Yes	NA
40418 PNM	1970-1979	0	Yes	NA
40419 PNM	1939 or earlier	60	Yes	NA
40420 PNM	1990 or later	20	No	NA
40421 PNM	1939 or earlier	0	NA	NA
40422 PNM	NA	100	Yes	NA
40424 PNM	NA	NA	NA	NA
40425 PNM	NA	NA	NA	NA
40428 PNM	1990 or later	100	Yes	Yes
40429 PNM	1939 or earlier	0	Yes	NA
40430 PNM	1970-1979	20	Yes	NA
40432 PNM	NA	NA	NA	NA
40433 PNM	1950-1959	NA	Yes	Yes
40434 PNM	1980-1989	0	Yes	Yes
40436 PNM	1940-1949	20	Yes	NA
40438 PNM	NA	20	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40439 PNM	1960-1969	100	No	NA
40440 PNM	1980-1989	100	No	NA
40441 PNM	1990 or later	0	Yes	NA
40442 PNM	1939 or earlier	100	Yes	Yes
40443 PNM	1939 or earlier	20	NA	NA
40444 PNM	NA	NA	NA	NA
40445 PNM	1950-1959	100	Yes	NA
40446 PNM	1970-1979	NA	Yes	NA
40447 PNM	1990 or later	100	No	NA
40449 PNM	1970-1979	0	Yes	NA
40451 PNM	NA	NA	Yes	NA
40453 PNM	1950-1959	100	Yes	NA
40454 PNM	1970-1979	0	Yes	NA
40455 PNM	NA	20	NA	NA
40456 PNM	NA	NA	Yes	NA
40457 PNM	1970-1979	100	Yes	NA
40458 PNM	NA	100	Yes	NA
40460 PNM	NA	100	NA	NA
40461 PNM	1990 or later	100	Yes	NA
40462 PNM	1940-1949	0	Yes	Yes
40463 PNM	NA	80	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40464 PNM	1939 or earlier	60	No	NA
40465 PNM	1990 or later	100	Yes	Yes
40466 PNM	1940-1949	80	Yes	NA
40467 PNM	1990 or later	100	No	NA
40468 PNM	1939 or earlier	NA	No	NA
40469 PNM	NA	NA	NA	NA
40470 PNM	NA	NA	NA	NA
40471 PNM	1980-1989	0	Yes	NA
40472 PNM	NA	100	NA	NA
40474 PNM	1960-1969	0	Yes	NA
40475 PNM	1939 or earlier	NA	Yes	NA
40476 PNM	1970-1979	0	Yes	NA
40478 PNM	1960-1969	40	Yes	NA
40480 PNM	1939 or earlier	60	Yes	NA
40481 PNM	1980-1989	20	Yes	NA
40482 PNM	1950-1959	NA	Yes	NA
40483 PNM	1939 or earlier	40	No	NA
40485 PNM	NA	NA	NA	NA
40489 PNM	NA	0	NA	NA
40490 PNM	NA	100	NA	NA
40491 PNM	1940-1949	0	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40492 PNM	NA	NA	NA	NA
40494 PNM	1939 or earlier	NA	Yes	NA
40495 PNM	NA	NA	NA	NA
40496 PNM	NA	0	NA	NA
40497 PNM	NA	NA	NA	NA
40498 PNM	NA	NA	NA	NA
40499 PNM	NA	0	NA	NA
40500 PNM	1950-1959	0	Yes	NA
40504 PNM	NA	NA	NA	NA
40505 PNM	1980-1989	100	Yes	NA
40506 PNM	NA	NA	No	NA
40507 PNM	NA	NA	NA	NA
40508 PNM	NA	NA	Yes	NA
40514 PNM	NA	100	NA	NA
40517 PNM	NA	20	Yes	NA
40518 PNM	NA	NA	NA	NA
40521 PNM	NA	100	Yes	NA
40522 PNM	NA	NA	NA	NA
40523 PNM	1990 or later	40	Yes	Yes
40525 PNM	1990 or later	20	Yes	NA
40526 PNM	NA	NA	Yes	No

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40527 PNM	NA	NA	Yes	Yes
40528 PNM	NA	NA	NA	NA
40529 PNM	NA	NA	NA	NA
40530 PNM	NA	0	NA	NA
40532 PNM	NA	NA	NA	NA
40533 PNM	1990 or later	100	No	NA
40535 PNM	NA	NA	No	NA
40537 PNM	NA	NA	NA	NA
40538 PNM	NA	NA	NA	NA
40539 PNM	1990 or later	100	Yes	NA
40541 PNM	NA	NA	NA	NA
40542 PNM	1990 or later	NA	Yes	NA
40543 PNM	NA	NA	NA	NA
40544 PNM	1939 or earlier	40	Yes	No
40545 PNM	1980-1989	NA	Yes	NA
40547 PNM	NA	0	NA	NA
40548 PNM	1990 or later	40	Yes	NA
40549 PNM	1939 or earlier	100	Yes	NA
40551 PNM	1970-1979	100	Yes	NA
40552 PNM	1970-1979	100	Yes	No
40554 PNM	NA	NA	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40556 PNM	1990 or later	0	Yes	NA
40557 PNM	1990 or later	NA	No	NA
40558 PNM	NA	0	NA	NA
40559 PNM	1970-1979	NA	Yes	NA
40560 PNM	1940-1949	NA	Yes	No
40561 PNM	1940-1949	40	Yes	NA
40563 PNM	NA	NA	NA	NA
40564 PNM	1990 or later	100	No	NA
40566 PNM	NA	NA	NA	NA
40568 PNM	1990 or later	0	Yes	NA
40571 PNM	1960-1969	NA	Yes	NA
40573 PNM	1990 or later	NA	Yes	NA
40575 PNM	1980-1989	100	Yes	NA
40576 PNM	1970-1979	80	Yes	NA
40579 PNM	NA	0	NA	NA
40580 PNM	1950-1959	100	No	NA
40583 PNM	NA	100	Yes	No
40584 PNM	1990 or later	NA	No	NA
40586 PNM	NA	NA	NA	NA
40587 PNM	1939 or earlier	100	Yes	NA
40588 PNM	1990 or later	NA	Yes	Yes

Sample ID	Home Characteristics			
	Home Built	Percent Carpet	Renovations	Furniture
40589 PNM	1960-1969	0	Yes	NA
40590 PNM	NA	60	NA	NA
40592 PNM	NA	40	NA	NA
40593 PNM	NA	NA	NA	NA
40594 PNM	1970-1979	0	Yes	NA
40600 PNM	NA	NA	Yes	NA
40602 PNM	NA	100	NA	NA
40603 PNM	NA	0	NA	NA
40604 PNM	NA	100	NA	NA
40605 PNM	1970-1979	80	No	NA
40607 PNM	NA	100	No	NA
40611 PNM	1990 or later	NA	No	NA
40612 PNM	NA	NA	NA	NA
40613 PNM	1939 or earlier	0	Yes	NA
40614 PNM	NA	100	NA	NA
40616 PNM	NA	100	No	No
40620 PNM	NA	NA	NA	NA
40623 PNM	NA	0	NA	NA
40625 PNM	1970-1979	0	No	NA
40628 PNM	NA	100	NA	NA
40629 PNM	1990 or later	NA	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40630 PNM	1970-1979	NA	Yes	NA
40631 PNM	1960-1969	100	Yes	NA
40632 PNM	1950-1959	NA	Yes	NA
40633 PNM	NA	20	NA	NA
40644 PNM	1939 or earlier	0	Yes	NA
40646 PNM	NA	0	NA	NA
40647 PNM	1939 or earlier	40	No	NA
40648 PNM	1939 or earlier	NA	Yes	NA
40649 PNM	1970-1979	100	Yes	NA
40650 PNM	NA	80	NA	NA
40651 PNM	1939 or earlier	NA	No	Yes
40652 PNM	NA	20	NA	NA
40653 PNM	NA	0	NA	NA
40654 PNM	NA	100	NA	NA
40656 PNM	1939 or earlier	100	Yes	NA
40659 PNM	NA	NA	NA	NA
40661 PNM	NA	20	NA	NA
40662 PNM	1990 or later	100	Yes	NA
40663 PNM	NA	0	NA	NA
40664 PNM	1950-1959	NA	Yes	NA
40665 PNM	NA	NA	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40667 PNM	NA	0	NA	NA
40668 PNM	NA	NA	NA	NA
40669 PNM	NA	20	NA	NA
40670 PNM	1939 or earlier	100	No	NA
40671 PNM	NA	NA	NA	NA
40673 PNM	NA	NA	NA	NA
40674 PNM	NA	20	NA	NA
40676 PNM	1990 or later	NA	Yes	NA
40677 PNM	NA	100	NA	NA
40680 PNM	NA	NA	NA	NA
40683 PNM	NA	100	Yes	No
40686 PNM	NA	100	NA	NA
40688 PNM	NA	NA	NA	NA
40689 PNM	NA	NA	NA	NA
40690 PNM	NA	100	NA	NA
40691 PNM	1939 or earlier	20	Yes	NA
40692 PNM	1939 or earlier	40	Yes	NA
40693 PNM	1970-1979	40	Yes	NA
40694 PNM	1990 or later	NA	Yes	NA
40695 PNM	1939 or earlier	NA	Yes	NA
40696 PNM	1939 or earlier	100	Yes	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40697 PNM	NA	100	NA	NA
40698 PNM	NA	NA	NA	NA
40699 PNM	NA	60	NA	NA
40704 PNM	NA	100	NA	NA
40705 PNM	1990 or later	0	Yes	NA
40706 PNM	NA	NA	NA	NA
40707 PNM	NA	100	NA	NA
40708 PNM	NA	NA	NA	NA
40709 PNM	NA	NA	NA	No
40710 PNM	1940-1949	0	Yes	NA
40711 PNM	NA	0	NA	NA
40712 PNM	1950-1959	100	Yes	NA
40713 PNM	NA	100	NA	NA
40718 PNM	NA	NA	NA	NA
40719 PNM	NA	NA	NA	NA
40720 PNM	1990 or later	100	Yes	NA
40722 PNM	NA	60	NA	NA
40723 PNM	1970-1979	100	Yes	NA
40724 PNM	NA	NA	NA	NA
40725 PNM	NA	80	NA	NA
40726 PNM	NA	100	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40727 PNM	NA	60	NA	NA
40730 PNM	NA	100	No	NA
40731 PNM	NA	NA	NA	NA
40732 PNM	NA	NA	NA	NA
40739 PNM	1990 or later	NA	Yes	NA
40740 PNM	NA	0	NA	NA
40745 PNM	NA	NA	NA	NA
40792 PNM	NA	100	NA	NA
40834 PNM	NA	NA	NA	NA
40890 PNM	NA	NA	NA	NA
40891 PNM	NA	NA	NA	NA
40893 PNM	NA	40	NA	NA
40894 PNM	NA	NA	NA	NA
40925 PNM	NA	80	NA	NA
40931 PNM	NA	NA	NA	NA
40955 PNM	NA	60	NA	NA
41077 PNM	NA	NA	NA	NA

Home Built = When the participants home was built

Percent Carpet = Percentage of carpet in participants' most used room in their home

Renovations = Whether or not participants' did home renovations in the previous 12 months

Furniture = Whether or not participants' brought new furniture into their home in the previous six months

NA = not applicable due to missing surveys, missing survey questions, or participant did not know answer to the question.

Appendix P: Total n values for postnatal maternal characteristics used to evaluate maternal plasma one year after delivery. Units and notes for columns are described at the bottom of the table.

	Maternal Characteristics		
	Age	**Deliveries**	**Duration Breastfed**
n value	247	63 (1), 57 (2), 24 (3 or more)	15 (0 months), 18 (1-3 months), 20 (4-6 months), 22 (7-9 months), 93 (10-12 months)

Age = Age of mother at time of blood draw

Deliveries = Number of babies delivered by mother written as n value (number of deliveries)

Duration Breastfed = Duration of breastfeeding by mother

Appendix Q: Postnatal maternal characteristics for individual samples used to evaluate maternal plasma one year after delivery. Units and notes for columns are described at the bottom of the table.

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40004 1YRM	35.9	NA	NA
40013 1YRM	30.8	NA	NA
40014 1YRM	36.9	NA	NA
40016 1YRM	35.3	NA	NA
40024 1YRM	28.3	NA	NA
40025 1YRM	36.7	NA	NA
40027 1YRM	30.8	NA	NA
40028 1YRM	29.8	NA	NA
40030 1YRM	30.7	NA	NA
40032 1YRM	36.7	NA	NA
40033 1YRM	26.7	NA	NA
40036 1YRM	29.8	NA	NA
40040 1YRM	33.6	NA	NA
40043 1YRM	29.9	NA	NA
40047 1YRM	32.1	NA	NA
40048 1YRM	36.4	NA	NA
40051 1YRM	43.7	NA	NA
40052 1YRM	37.8	NA	NA

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40054 1YRM	37.9	NA	NA
40057 1YRM	30.5	NA	NA
40060 1YRM	39.4	2	NA
40062 1YRM	33.4	1	6
40064 1YRM	39.7	2	0
40065 1YRM	33.4	2	12
40066 1YRM	33.2	1	12
40067 1YRM	39.9	2	12
40069 1YRM	30.9	1	12
40071 1YRM	31.8	2	10
40074 1YRM	33.5	3	12
40076 1YRM	33.7	1	9
40077 1YRM	36.3	NA	0
40078 1YRM	30.6	2	10
40081 1YRM	40.2	2	0
40082 1YRM	32.9	NA	12
40083 1YRM	32.7	NA	8
40085 1YRM	30	1	10
40086 1YRM	29.2	3	12
40087 1YRM	30.9	NA	12
40089 1YRM	39.5	3	12

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40090 1YRM	27.7	2	0
40092 1YRM	31.7	1	12
40094 1YRM	40	2	12
40095 1YRM	31.7	1	NA
40097 1YRM	29.8	1	12
40098 1YRM	23.9	NA	2
40099 1YRM	37.4	NA	0
40100 1YRM	25.8	1	12
40101 1YRM	32.5	2	11
40102 1YRM	31.8	NA	12
40103 1YRM	34.4	2	7
40104 1YRM	29.7	1	12
40105 1YRM	33.4	2	0
40106 1YRM	32.3	2	0
40107 1YRM	32.7	NA	10
40110 1YRM	39.8	3	11
40111 1YRM	40.8	2	0
40114 1YRM	34.7	2	12
40115 1YRM	34.8	NA	12
40116 1YRM	28	NA	12
40117 1YRM	31.1	NA	10

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40118 1YRM	35.3	NA	3
40120 1YRM	32.4	2	10
40123 1YRM	31.6	1	12
40124 1YRM	34.6	NA	NA
40126 1YRM	33.4	2	12
40128 1YRM	37.6	1	12
40129 1YRM	38.2	3	12
40132 1YRM	41.9	4	12
40134 1YRM	33	2	12
40135 1YRM	31.4	NA	12
40136 1YRM	26.2	NA	0
40137 1YRM	28.8	2	12
40138 1YRM	30.7	NA	12
40139 1YRM	30	NA	12
40140 1YRM	33.6	NA	10
40141 1YRM	28.8	NA	NA
40142 1YRM	35.7	NA	NA
40143 1YRM	39.4	NA	9
40144 1YRM	31	NA	10
40146 1YRM	40.8	1	12
40147 1YRM	33	NA	0

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40148 1YRM	39.5	NA	10
40150 1YRM	36.9	2	12
40156 1YRM	32.8	2	12
40157 1YRM	24.5	1	0
40158 1YRM	30.1	NA	5
40159 1YRM	34.2	1	12
40161 1YRM	28.1	1	6
40162 1YRM	32.6	2	6
40164 1YRM	31.4	NA	9
40166 1YRM	33.5	1	4
40169 1YRM	36.5	NA	NA
40170 1YRM	24.4	2	5
40172 1YRM	28.7	NA	12
40174 1YRM	29	NA	12
40175 1YRM	35.3	NA	NA
40176 1YRM	35.4	2	12
40177 1YRM	41.4	2	12
40178 1YRM	33.7	2	1
40179 1YRM	28.8	1	6
40180 1YRM	31.9	1	8
40183 1YRM	34.3	3	12

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40184 1YRM	32	1	10
40185 1YRM	30.7	1	12
40186 1YRM	37.6	3	11
40187 1YRM	38.9	1	10
40188 1YRM	39.4	NA	6
40189 1YRM	32.6	2	NA
40190 1YRM	30.7	2	12
40192 1YRM	35.9	NA	6
40193 1YRM	22.3	1	1
40194 1YRM	32.4	NA	0
40195 1YRM	34.9	3	12
40196 1YRM	32.6	1	12
40197 1YRM	28.4	1	12
40198 1YRM	32.9	NA	11
40203 1YRM	35.7	NA	11
40205 1YRM	33.7	NA	12
40206 1YRM	32.6	1	12
40207 1YRM	34	2	2
40209 1YRM	35.7	NA	7
40211 1YRM	35.2	NA	NA
40216 1YRM	38.5	NA	12

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40218 1YRM	33.4	1	12
40225 1YRM	30.5	NA	6
40232 1YRM	32.2	2	NA
40235 1YRM	29.3	1	NA
40239 1YRM	28	1	3
40240 1YRM	37.3	2	NA
40243 1YRM	34.7	2	8
40244 1YRM	28.8	NA	10
40245 1YRM	35.9	2	4
40246 1YRM	32.4	1	NA
40247 1YRM	36.5	3	12
40250 1YRM	34.1	2	12
40252 1YRM	35	6	NA
40254 1YRM	35.5	2	12
40255 1YRM	37.6	3	12
40256 1YRM	27.7	2	12
40257 1YRM	28.2	2	6
40258 1YRM	36	NA	2
40259 1YRM	30.3	1	2
40261 1YRM	33.8	1	12
40264 1YRM	35.3	2	9

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40265 1YRM	39.4	1	10
40266 1YRM	32.2	1	12
40268 1YRM	33.5	NA	9
40269 1YRM	29.6	1	7
40271 1YRM	27.1	1	1
40272 1YRM	33	2	0
40273 1YRM	31	2	12
40274 1YRM	34.3	NA	7
40276 1YRM	29.8	2	NA
40277 1YRM	31.3	3	12
40279 1YRM	25.4	1	2
40280 1YRM	32.9	2	NA
40283 1YRM	37.5	1	NA
40284 1YRM	34.4	3	12
40289 1YRM	41	NA	3
40290 1YRM	32.4	NA	7
40291 1YRM	30.5	3	NA
40295 1YRM	34.8	2	4
40297 1YRM	30.8	NA	12
40301 1YRM	23.6	1	1
40302 1YRM	22.1	NA	1

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40304 1YRM	34.2	2	NA
40306 1YRM	31.6	2	NA
40312 1YRM	37.9	NA	12
40313 1YRM	24.5	NA	NA
40316 1YRM	39.8	3	4
40320 1YRM	30.5	NA	NA
40321 1YRM	30.1	2	12
40322 1YRM	26.1	NA	12
40324 1YRM	34.2	NA	8
40326 1YRM	31.9	NA	12
40327 1YRM	33.3	NA	2
40329 1YRM	36.1	NA	12
40334 1YRM	29.7	1	12
40344 1YRM	21.7	1	1
40370 1YRM	26.2	1	4
40382 1YRM	32	1	12
40384 1YRM	35.2	2	12
40405 1YRM	30.7	3	NA
40411 1YRM	38.1	NA	NA
40412 1YRM	25.5	3	9
40428 1YRM	30.5	2	8

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40429 1YRM	31.7	NA	NA
40441 1YRM	21.8	1	NA
40445 1YRM	31.9	NA	NA
40447 1YRM	33.1	1	NA
40449 1YRM	26.1	NA	NA
40451 1YRM	24.7	NA	8
40454 1YRM	36.4	NA	9
40456 1YRM	33.4	NA	NA
40458 1YRM	25.2	2	NA
40459 1YRM	26.6	NA	6
40460 1YRM	32.3	2	NA
40461 1YRM	27.6	1	1
40464 1YRM	34.4	1	NA
40465 1YRM	32.7	1	12
40466 1YRM	25	1	10
40467 1YRM	31.8	3	NA
40469 1YRM	28.5	NA	NA
40470 1YRM	23.2	2	NA
40474 1YRM	31.9	4	NA
40478 1YRM	31.4	2	NA
40480 1YRM	30.2	NA	NA

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40485 1YRM	33.9	NA	NA
40490 1YRM	32.9	3	NA
40491 1YRM	29.6	1	12
40492 1YRM	27.9	NA	NA
40499 1YRM	26.1	NA	12
40500 1YRM	26.1	1	NA
40502 1YRM	29.1	NA	9
40509 1YRM	31.6	1	7
40514 1YRM	23.2	NA	1
40523 1YRM	28	1	12
40525 1YRM	31.1	NA	NA
40530 1YRM	32.1	NA	9
40532 1YRM	28.6	4	NA
40541 1YRM	29.9	NA	NA
40543 1YRM	30.9	2	NA
40544 1YRM	37.5	2	10
40547 1YRM	35	2	5
40548 1YRM	35.2	1	4
40551 1YRM	31.4	NA	12
40552 1YRM	32.2	1	4
40564 1YRM	27.4	NA	4

Sample ID	Maternal Characteristics		
	Age	Deliveries	Duration Breastfed
40568 1YRM	27.3	1	2
40579 1YRM	38	1	0
40581 1YRM	37.1	3	NA
40586 1YRM	32.9	2	NA
40587 1YRM	35.3	NA	NA
40589 1YRM	33.2	NA	NA
40594 1YRM	25.6	1	12
40602 1YRM	27.5	NA	NA
40605 1YRM	32.2	NA	8
40607 1YRM	22.7	1	12
40611 1YRM	32.7	2	0
40614 1YRM	28.3	1	NA
40616 1YRM	31.6	1	NA
40633 1YRM	32.2	1	NA
40646 1YRM	42.3	NA	NA
40652 1YRM	40.2	3	12
40662 1YRM	32.5	NA	NA
40670 1YRM	43.7	NA	NA
40719 1YRM	34.8	1	NA

Age = Age of mother at time of blood draw (years)

Deliveries = Number of babies delivered by mother

Duration Breastfed = Duration of breastfeeding by mother (months)

NA = not applicable due to missing surveys, missing survey questions, participant did not know answer to the question or not available from medical records.

Appendix R: Total n values for home characteristics used to evaluate maternal plasma one year after delivery. Notes for columns are described at the bottom of the table.

	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
n value	32 (1939 or earlier), 17 (1940-1949), 23 (1950-1959), 19 (1960-1969), 30 (1970-1979), 20 (1980-1989), 29 (1990 or later)	67 (0%), 18 (20%), 25 (40%), 11 (60%), 7 (80%), 71 (100%)	43 (no), 22 (yes)	52 (no), 13 (yes)

Home Built = When the participants home was built

Percent Carpet = Percentage of carpet in participants' most used room in their home

Renovations = Whether or not participants' did home renovations in the previous six months

Furniture = Whether or not participants' brought new furniture into their home in the previous six months

Appendix S: Home characteristics for individual samples used to evaluate maternal plasma one year after delivery. Units and notes for columns are described at the bottom of the table.

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40004 1YRM	NA	NA	NA	NA
40013 1YRM	NA	NA	NA	NA
40014 1YRM	NA	NA	NA	NA
40016 1YRM	NA	NA	NA	NA
40024 1YRM	NA	NA	NA	NA
40025 1YRM	NA	NA	NA	NA
40027 1YRM	NA	NA	NA	NA
40028 1YRM	NA	NA	NA	NA
40030 1YRM	NA	NA	NA	NA
40032 1YRM	NA	NA	NA	NA
40033 1YRM	NA	NA	NA	NA
40036 1YRM	NA	NA	NA	NA
40040 1YRM	NA	NA	NA	NA
40043 1YRM	NA	NA	NA	NA
40047 1YRM	NA	NA	NA	NA
40048 1YRM	NA	NA	NA	NA
40051 1YRM	NA	NA	NA	NA
40052 1YRM	NA	NA	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40054 1YRM	NA	NA	NA	NA
40057 1YRM	NA	NA	NA	NA
40060 1YRM	1939 or earlier	40	NA	NA
40062 1YRM	1940-1949	0	NA	NA
40064 1YRM	1990 or later	100	NA	NA
40065 1YRM	1940-1949	20	NA	NA
40066 1YRM	1990 or later	100	NA	NA
40067 1YRM	1950-1959	100	NA	NA
40069 1YRM	1980-1989	40	NA	NA
40071 1YRM	1990 or later	100	NA	NA
40074 1YRM	1950-1959	100	NA	NA
40076 1YRM	1990 or later	100	NA	NA
40077 1YRM	1940-1949	0	NA	NA
40078 1YRM	1939 or earlier	40	NA	NA
40081 1YRM	1950-1959	0	NA	NA
40082 1YRM	1990 or later	0	NA	NA
40083 1YRM	1990 or later	100	NA	NA
40085 1YRM	1980-1989	100	NA	NA
40086 1YRM	1970-1979	40	NA	NA
40087 1YRM	1940-1949	40	NA	NA
40089 1YRM	1950-1959	0	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40090 1YRM	1980-1989	60	NA	NA
40092 1YRM	1939 or earlier	100	NA	NA
40094 1YRM	1990 or later	100	NA	NA
40095 1YRM	1940-1949	40	NA	NA
40097 1YRM	NA	0	NA	NA
40098 1YRM	1940-1949	0	NA	NA
40099 1YRM	NA	NA	NA	NA
40100 1YRM	1980-1989	100	NA	NA
40101 1YRM	1960-1969	0	NA	NA
40102 1YRM	1960-1969	NA	NA	NA
40103 1YRM	1960-1969	100	NA	NA
40104 1YRM	1950-1959	40	NA	NA
40105 1YRM	1939 or earlier	100	NA	NA
40106 1YRM	1940-1949	NA	NA	NA
40107 1YRM	1950-1959	20	NA	NA
40110 1YRM	1950-1959	60	NA	NA
40111 1YRM	1940-1949	0	NA	NA
40114 1YRM	1950-1959	20	NA	NA
40115 1YRM	1970-1979	60	NA	NA
40116 1YRM	1950-1959	NA	NA	NA
40117 1YRM	1970-1979	0	NA	NA

Sample ID	Home Characteristics			
	Home Built	Percent Carpet	Renovations	Furniture
40118 1YRM	1970-1979	0	NA	NA
40120 1YRM	1939 or earlier	NA	NA	NA
40123 1YRM	1939 or earlier	0	NA	NA
40124 1YRM	1960-1969	100	NA	NA
40126 1YRM	1970-1979	0	NA	NA
40128 1YRM	NA	100	NA	NA
40129 1YRM	1980-1989	0	NA	NA
40132 1YRM	1970-1979	20	NA	NA
40134 1YRM	1990 or later	100	NA	NA
40135 1YRM	1960-1969	40	NA	NA
40136 1YRM	1950-1959	0	NA	NA
40137 1YRM	NA	80	NA	NA
40138 1YRM	1960-1969	40	NA	NA
40139 1YRM	1980-1989	100	NA	NA
40140 1YRM	1970-1979	100	NA	NA
40141 1YRM	NA	80	NA	NA
40142 1YRM	1970-1979	0	NA	NA
40143 1YRM	1970-1979	100	NA	NA
40144 1YRM	1990 or later	100	NA	NA
40146 1YRM	NA	0	NA	NA
40147 1YRM	1960-1969	100	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40148 1YRM	1939 or earlier	40	NA	NA
40150 1YRM	NA	0	NA	NA
40156 1YRM	1980-1989	NA	NA	NA
40157 1YRM	NA	100	NA	NA
40158 1YRM	1970-1979	80	NA	NA
40159 1YRM	NA	80	NA	NA
40161 1YRM	1939 or earlier	100	NA	NA
40162 1YRM	1950-1959	0	NA	NA
40164 1YRM	1970-1979	0	NA	NA
40166 1YRM	1940-1949	100	NA	NA
40169 1YRM	1980-1989	60	NA	NA
40170 1YRM	1939 or earlier	40	NA	NA
40172 1YRM	NA	20	NA	NA
40174 1YRM	1950-1959	40	NA	NA
40175 1YRM	1960-1969	0	NA	NA
40176 1YRM	1970-1979	0	NA	NA
40177 1YRM	1939 or earlier	0	NA	NA
40178 1YRM	NA	NA	NA	NA
40179 1YRM	NA	20	NA	NA
40180 1YRM	1980-1989	100	NA	NA
40183 1YRM	NA	0	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40184 1YRM	1990 or later	20	NA	NA
40185 1YRM	NA	100	NA	NA
40186 1YRM	1939 or earlier	0	NA	NA
40187 1YRM	1970-1979	NA	NA	NA
40188 1YRM	NA	0	NA	NA
40189 1YRM	1939 or earlier	100	NA	NA
40190 1YRM	1939 or earlier	100	NA	NA
40192 1YRM	1939 or earlier	100	NA	NA
40193 1YRM	1970-1979	100	NA	NA
40194 1YRM	NA	100	NA	NA
40195 1YRM	1939 or earlier	20	NA	NA
40196 1YRM	NA	NA	NA	NA
40197 1YRM	NA	100	NA	NA
40198 1YRM	1960-1969	0	NA	NA
40203 1YRM	1980-1989	100	NA	NA
40205 1YRM	NA	100	NA	NA
40206 1YRM	NA	NA	NA	NA
40207 1YRM	NA	60	NA	NA
40209 1YRM	1990 or later	100	NA	NA
40211 1YRM	1939 or earlier	0	NA	NA
40216 1YRM	1990 or later	0	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40218 1YRM	1950-1959	100	NA	NA
40225 1YRM	1990 or later	100	NA	NA
40232 1YRM	1970-1979	0	NA	NA
40235 1YRM	NA	NA	NA	NA
40239 1YRM	1970-1979	0	NA	NA
40240 1YRM	NA	NA	NA	NA
40243 1YRM	NA	100	NA	NA
40244 1YRM	1970-1979	20	NA	NA
40245 1YRM	NA	100	NA	NA
40246 1YRM	1990 or later	100	NA	NA
40247 1YRM	1939 or earlier	60	NA	NA
40250 1YRM	1990 or later	100	NA	NA
40252 1YRM	1940-1949	80	NA	NA
40254 1YRM	1990 or later	100	NA	NA
40255 1YRM	NA	NA	NA	NA
40256 1YRM	NA	NA	NA	NA
40257 1YRM	1960-1969	0	NA	NA
40258 1YRM	1960-1969	40	NA	NA
40259 1YRM	1939 or earlier	60	NA	NA
40261 1YRM	NA	NA	NA	NA
40264 1YRM	NA	100	NA	NA

Sample ID	Home Characteristics			
	Home Built	Percent Carpet	Renovations	Furniture
40265 1YRM	1940-1949	0	NA	NA
40266 1YRM	NA	NA	NA	NA
40268 1YRM	NA	0	NA	NA
40269 1YRM	1950-1959	0	NA	NA
40271 1YRM	NA	NA	NA	NA
40272 1YRM	1939 or earlier	0	NA	NA
40273 1YRM	NA	100	NA	NA
40274 1YRM	1990 or later	40	NA	NA
40276 1YRM	1990 or later	20	NA	NA
40277 1YRM	NA	0	NA	NA
40279 1YRM	NA	NA	NA	NA
40280 1YRM	NA	NA	NA	NA
40283 1YRM	NA	NA	NA	NA
40284 1YRM	1939 or earlier	40	NA	NA
40289 1YRM	NA	0	NA	NA
40290 1YRM	1990 or later	40	NA	NA
40291 1YRM	1970-1979	100	NA	NA
40295 1YRM	1970-1979	100	NA	NA
40297 1YRM	1990 or later	100	NA	NA
40301 1YRM	1990 or later	0	NA	NA
40302 1YRM	NA	0	NA	NA

Sample ID	Home Characteristics			
	Home Built	Percent Carpet	Renovations	Furniture
40304 1YRM	NA	0	NA	NA
40306 1YRM	NA	NA	NA	NA
40312 1YRM	1939 or earlier	100	NA	NA
40313 1YRM	1960-1969	0	NA	NA
40316 1YRM	1970-1979	0	NA	NA
40320 1YRM	NA	100	NA	NA
40321 1YRM	1970-1979	80	NA	NA
40322 1YRM	NA	100	NA	NA
40324 1YRM	1990 or later	NA	NA	NA
40326 1YRM	NA	100	NA	NA
40327 1YRM	NA	100	NA	NA
40329 1YRM	NA	20	NA	NA
40334 1YRM	NA	0	NA	NA
40344 1YRM	NA	20	NA	NA
40370 1YRM	1990 or later	100	NA	NA
40382 1YRM	1939 or earlier	100	NA	NA
40384 1YRM	NA	NA	NA	NA
40405 1YRM	NA	NA	NA	NA
40411 1YRM	NA	NA	NA	NA
40412 1YRM	NA	NA	NA	NA
40428 1YRM	NA	NA	NA	NA

Sample ID	Home Characteristics			
	Home Built	Percent Carpet	Renovations	Furniture
40429 1YRM	NA	NA	NA	NA
40441 1YRM	NA	NA	NA	NA
40445 1YRM	NA	NA	NA	NA
40447 1YRM	NA	NA	NA	NA
40449 1YRM	NA	NA	NA	NA
40451 1YRM	NA	NA	NA	NA
40454 1YRM	NA	NA	NA	NA
40456 1YRM	NA	NA	NA	NA
40458 1YRM	NA	NA	NA	NA
40459 1YRM	NA	NA	NA	NA
40460 1YRM	NA	NA	NA	NA
40461 1YRM	NA	NA	NA	NA
40464 1YRM	NA	NA	NA	NA
40465 1YRM	NA	NA	NA	NA
40466 1YRM	NA	NA	NA	NA
40467 1YRM	NA	NA	NA	NA
40469 1YRM	1939 or earlier	40	NA	NA
40470 1YRM	1940-1949	0	NA	NA
40474 1YRM	1990 or later	100	NA	NA
40478 1YRM	1940-1949	20	NA	NA
40480 1YRM	1990 or later	100	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40485 1YRM	1950-1959	100	NA	NA
40490 1YRM	1980-1989	40	NA	NA
40491 1YRM	1990 or later	100	NA	NA
40492 1YRM	1950-1959	100	NA	NA
40499 1YRM	1990 or later	100	NA	NA
40500 1YRM	1940-1949	0	NA	NA
40502 1YRM	1939 or earlier	40	NA	NA
40509 1YRM	1950-1959	0	NA	NA
40514 1YRM	1990 or later	0	NA	NA
40523 1YRM	1990 or later	100	NA	NA
40525 1YRM	1980-1989	100	NA	NA
40530 1YRM	1970-1979	40	NA	NA
40532 1YRM	1940-1949	40	NA	NA
40541 1YRM	1950-1959	0	NA	NA
40543 1YRM	1980-1989	60	NA	NA
40544 1YRM	1939 or earlier	100	NA	NA
40547 1YRM	1990 or later	100	NA	NA
40548 1YRM	1940-1949	40	NA	NA
40551 1YRM	NA	0	NA	NA
40552 1YRM	1940-1949	0	NA	NA
40564 1YRM	NA	NA	NA	NA

Sample ID	Home Characteristics			
	Home Built	**Percent Carpet**	**Renovations**	**Furniture**
40568 1YRM	1980-1989	100	NA	NA
40579 1YRM	1960-1969	0	NA	NA
40581 1YRM	1960-1969	NA	NA	NA
40586 1YRM	1960-1969	100	NA	NA
40587 1YRM	1950-1959	40	NA	NA
40589 1YRM	1939 or earlier	100	NA	NA
40594 1YRM	1940-1949	NA	NA	NA
40602 1YRM	1950-1959	20	NA	NA
40605 1YRM	1950-1959	60	NA	NA
40607 1YRM	1940-1949	0	NA	NA
40611 1YRM	1950-1959	20	NA	NA
40614 1YRM	1970-1979	60	NA	NA
40616 1YRM	1950-1959	NA	NA	NA
40633 1YRM	1970-1979	0	NA	NA
40646 1YRM	1970-1979	0	NA	NA
40652 1YRM	1939 or earlier	NA	NA	NA
40662 1YRM	1939 or earlier	0	NA	NA
40670 1YRM	1960-1969	100	NA	NA
40719 1YRM	1970-1979	0	NA	NA

Home Built = When the participants home was built

Percent Carpet = Percentage of carpet in participants' most used room in their home

Renovations = Whether or not participants' did home renovations in the previous six months

Furniture = Whether or not participants' brought new furniture into their home in the previous six months

NA = not applicable due to missing surveys, missing survey questions, participant did not know answer to the question or not available from medical records.