

PP4.2. PFAS KAO TIHI PROGRAMERI LJUDSKOG ZDRAVLJA: PRENATALNA IZLOŽENOST, EFEKTI NISKIH DOZA I RIZIK ZA BUDUĆE GENERACIJE

E. Omeragić

Univerzitet u Sarajevu – Farmaceutski fakultet, Sarajevo, Bosna i Hercegovina

Per- i polifluorisane alkilne supstance (PFAS) predstavljaju postojane i široko rasprostranjene kontaminante životne sredine od značaja za javno zdravlje. Zbog hemijske stabilnosti, bioakumulacije i primene u industrijskim i potrošačkim proizvodima, izloženost PFAS jedinjenjima postala je gotovo neizbežna, uključujući trudnoću i rani život. Prenatalni period je posebno osetljiv razvojni prozor, tokom kojeg i niske doze endokrinih disruptora mogu uticati na fetalno programiranje i dugoročne zdravstvene ishode.

Posebnu zabrinutost izaziva sposobnost PFAS jedinjenja da prolaze placentarnu barijeru i dospevaju do fetusa. Prenatalna izloženost povezuje se sa mogućim poremećajima endokrinih, metaboličkih, imunoloških i razvojnih puteva, pri čemu se posledice mogu ispoljiti tek kasnije tokom života. Koncept PFAS jedinjenja kao „tihih programera“ ljudskog zdravlja odražava njihovu sposobnost da menjaju biološke procese u ključnim fazama razvoja, često bez neposredno vidljivih kliničkih manifestacija. Efekti niskih doza, nemonotoni odnosi doza–odgovor i kombinovana izloženost hemijskim smešama dodatno otežavaju klasičnu toksikološku procenu rizika.

Humani biomonitoring, zasnovan na uparenim uzorcima krvi majke i pupčanika, placentarnom tkivu i ranim biomarkerima, ključan je za razumevanje maternalno-fetalnog prenosa i ranih bioloških odgovora. Regionalne kohortne studije majka–dete, uključujući TOXMOM i PrenTox, doprinose boljem razumevanju prenatalne izloženosti PFAS jedinjenjima i drugim endokrinim disruptorima u populacijama sa ograničenim biomonitoring podacima. Prenatalna izloženost PFAS jedinjenjima zato predstavlja važno pitanje toksikologije životne sredine, reproduktivnog zdravlja, razvoja dece i javnozdravstvene prevencije.

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PP4.2. PFAS AS SILENT PROGRAMMERS OF HUMAN HEALTH: PRENATAL EXPOSURE, LOW-DOSE EFFECTS, AND INTERGENERATIONAL RISK

E. Omeragić

University of Sarajevo – Faculty of Pharmacy, Sarajevo, Bosnia and Herzegovina

Per- and polyfluoroalkyl substances (PFAS) are persistent environmental contaminants. Due to their chemical stability, bioaccumulative potential, and use in industrial and consumer products, human exposure to PFAS has become unavoidable. The prenatal period represents a sensitive developmental window, during which even low-level exposure to endocrine-disrupting chemicals may interfere with fetal programming and contribute to long-term health outcomes.

PFAS are of particular concern because they can cross the placental barrier. Prenatal exposure has been associated with disturbances in endocrine, metabolic, immune, and developmental pathways, with consequences that may become evident later in life. The concept of PFAS as “silent programmers” of human health reflects their capacity to alter biological processes during critical stages of development, often without immediate clinical manifestations. Low-dose effects, non-monotonic dose–response relationships, and combined exposure to chemical mixtures further complicate toxicological risk assessment.

Human biomonitoring studies based on paired maternal and umbilical cord blood samples, placental tissue, and early-life biomarkers are essential for understanding maternal–fetal transfer and early biological responses. Regional mother–child cohort studies, including TOXMOM and PrenTox, contribute to evidence on prenatal exposure to PFAS and other endocrine-disrupting chemicals, particularly in populations with limited biomonitoring data.

Prenatal PFAS exposure represents an important issue at the intersection of environmental toxicology, reproductive health, child development, and public health prevention. Improved exposure assessment, early preventive strategies, and communication among researchers, healthcare professionals, pharmacists, policymakers, and the public are needed to reduce risks for future generations.

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