Developing Brains-
Ideas for Parenting and Education
From the New Brain Science
www.developingbrains.org

Effects of Maternal Cigarette Smoking
On
Fetal Brain Development and Later Behavior

In addition to the typical prediction of low birth weight in babies exposed to cigarette smoke during fetal development, recent research has pointed out that cigarette smoking has a very disruptive effect on the developing brain. This disruption occurs throughout the fetal period, (which contradicts our prior notion that the most damage to the fetal brain occurs during the first trimester). In addition, the damaging effects of cigarette smoke extend throughout childhood and into adolescence. (Slotkin 2004)

Lack of Oxygen

One cause of neurological dysfunction is the restriction of oxygen to the fetus. The blood carries oxygen to all cells via hemoglobin. When a fetus is exposed to cigarette smoke, the carbon monoxide from the smoke is carried by the hemoglobin to the cells rather than oxygen. As a result, overall growth is decreased. (NSCDC, No. 4, 2006) In one study, the carbon monoxide levels in fetuses exposed to cigarette smoke during development were twice that of their mothers. (Pressinger 2003)

Nicotine

Nicotine, a neurotoxin, is considered to be a "neuroteratogen", meaning that exposure to it during fetal development disrupts the development of the brain. Exposure may come from maternal smoking during pregnancy and/or from exposure to second-hand smoke (also called environmental tobacco smoke or ETS). The extent of disruption in development is "dose" related, meaning the greater the exposure to nicotine, the greater the damage to

the developing brain. According to Slotkin (2004), nicotine levels in second-hand smoke may, themselves, be "enough to cause significant changes both in the fetal and adolescent brain."

Slotkin (2004) states that "in terms of the health impact on society, nicotine, in the form of maternal smoking, likely represents the single most important developmental neurotoxicant, involving as much as much as one-fourth of all pregnancies in the United States…" and environmental tobacco smoke (ETS) "adds to that total".

Nicotine (from cigarette smoke as well as from the nicotine patch) causes serious damage to the fetus even at exposure levels too low to cause low birth weight.

> Nicotine "mimics a key brain neurotransmitter chemical, acetylcholine, which is normally released in a precise sequence of signals that tell the sensitive growing brain cells how to 'wire' their connections. However, nicotine stimulates the same cell receptors as acetylcholine[1], at the wrong time and with inappropriate intensity, confusing the normal development process and causing the fetal brain to *permanently miswire itself*. Nicotine also kills brain cells outright by causing them to 'age' prematurely and die." (Slotkin, press release, 1998)

This cell loss has been found to continue "over the first two weeks postpartum, well after the termination of nicotine exposure. This suggests that nicotine initiates a change in the program for cell development" (Slotkin, 1998). This change is described as causing a *premature switch* from brain cell duplication (making more cells) to cell differentiation, leading to a major disruption in brain development with results which range from newborn death to outright brain damage to subtle cognitive defects (Slotkin 1998).

Nicotine has been found (in animal studies) to result in a reduction of the "thickness of the cerebral cortex, smaller cerebral cortex neurons, and

[1] Acetylcholine plays critical roles in "virtually all phases of brain maturation." (Slotkin 2004). Depending on which phase of brain development that the exposure occurs in, acetylcholine either "promotes or prevents" cell death. (Slotkin 2004)

reduced brain weight" as well as a reduction in "dendritic branching" (Pressinger 2003).

Risks to a Fetus

Cigarette smokers use cigarettes more or less continuously, thus when a pregnant woman smokes, she is allowing very little recovery time for the fetus. Round the clock use of a nicotine patch has the same continuous effect.

According to Slotkin (2004), exposure to tobacco smoke in utero "contributes in a major way to spontaneous abortions, intrauterine growth retardation, and perinatal deaths," as well as Sudden Infant Death Syndrome.

Effects Seen in Children

Though the cognitive effects of nicotine exposure during gestation are "significantly milder than those resulting from alcohol or other toxic chemicals," nicotine exposure does impact the "structure and function of the fetal brain." (NSCDC, No. 4, 2006) The general consensus from multiple studies about the effects of maternal smoking on children's general growth, brain development and behavior shows that children whose mother's smoked during pregnancy are more likely to show the following effects. (Pressinger 2003, Slotkin 1998, Slotkin 2004)

In newborns:

- Decreased newborn Apgar scores (if mother smoked more than one pack a day)
- Smaller head circumference in infants
- Increased risk of death from SIDS due to disruption in a neurological system which stimulates a reflex in the baby to respond to apnea (stopping breathing)

School performance and mental abilities:

- Reduced IQ
- Decreased mental performance scoring at age one year

- Decreased academic performance scores in the school-aged child (especially in math and reading, as well as general ability)
- Reduced auditory processing (listening skills) found in children exposed to maternal and passive smoke prenatally
- Increased rates of learning disabilities (children were 25% more likely to have learning disabilities if their mother smoked more than 20 cigarettes a day)
- More likely to experience failure in both school and career

Behavioral effects:

- Increased hyperactivity (in mothers who smoked an average of 14 cigarettes a day during pregnancy)
- Increased behavior problems, such as anxiety, conduct disorders, conflict with others, or disobedience in children exposed to cigarette smoke prenatally (with greater problems the more the mother smoked)
- Exposure to cigarette smoke prenatally has been identified as a "significant contributor to disruptive and criminal behaviors" (Slotkin 2004)
- Behavior problems (such as aggression, temper outburst, and stubborn refusal to follow directions) in children whose mothers smoked during pregnancy begin to show up as early as 18 to 24 months, as compared to toddlers whose mothers did not smoke during pregnancy

Impacts on growth and health:

- Shorter stature (by one or two centimeters) in children whose mothers who smoked 10 or more cigarettes a day
- Increased respiratory diseases
- Smoking cigarettes during adolescence increases the likelihood of becoming nicotine dependent

Implications:

Women who are of child-bearing age should be strongly encouraged to seek a method to stop smoking cigarettes. They should also seek support for this challenge from formal and/or informal sources. Women who are pregnant or are trying to become pregnant should avoid any exposure to second-hand smoke. Pregnant women who want to stop smoking should avoid use of

nicotine substitutes as part of the process. Furthermore, parents should ensure that their children are protected from exposure to second-hand smoke, both inside the home and out of the home.

References

Browning, Andrea, "Toddlers exposed to cigarette smoke in utero exhibit greater behavioral problems." Society for Research in Child Development, July 13, 2006.
http://www.eurekalert.org/pub_releases/w006-07/sfri-tet070706.php

Meredith, Dennis, "Preventing Poisoned Minds: Cigarette Babies." Duke Magazine Perspectives. (1/14/2003)
http://www.dukemagazine.duke.edu/alumni/dm17/slotkin.html

National Scientific Council on the Developing Child (NSCDC), "Early exposure to toxic substances damages brain architecture." (2006) Working Paper Number 4.
http://www.developingchild.net

Pressinger, Richard W., "Cigarette Smoking During Pregnancy: Links to Learning Disabilities, Attention Deficit Disorder – A.D.D. – Hyperactivity and Behavior Disorders" (1/14/2003)
http://www.chem-tox.com/pregnancy/smoking.htm

Slotkin, Theodore, "Cholinergic systems in brain development and disruption by neurotoxicants: nicotine, environmental tobacco smoke, organophosphates." Toxicology and Applied Pharmacology. Special Pediatric Volumne- online version. Volume 198, Issue 2, July 15, 2004, 132-151.

Slotkin, Theodore A., "Fetal Nicotine or Cocaine Exposure: Which One is Worse?" Journal of Pharmacology and Experimental Therapeutics. Vol. 283, Issue 3, June 1998, 931-945.

Kathy A. Bobula, Ph.D.
2008