Methodology, inference and causation
Environmental lead exposure and childhood intelligence

Gail A. Wasserman*, Pam Factor-Litvak

Columbia University, New York, NY, USA

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Abstract

Kaufman's critique of the literature on the associations between lead exposure and child intelligence raises important methodological and inferential points. We address the concerns he raises regarding measuring known and unknown confounders, statistical modeling, reverse casuality and quality control. Mismeasurement of potential confounders of the lead–IQ relationship, such as parenting skills, parental intelligence, maternal smoking during pregnancy, or otitis media can either strengthen or weaken the estimated association between exposure and child intelligence. Despite some variability in design and measurement, a series of comprehensive prospective investigations in varied populations, by different sets of investigators, provide consistent replication; taken together these studies point to the conclusion that lead exposure has adverse consequences for child development, and that the deficits are likely to be small in comparison to the contribution of measured social factors. © 2001 National Academy of Neuropsychology. Published by Elsevier Science Ltd.

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In 1979, Needleman et al. published a landmark report that low levels of lead exposure (in shed teeth) were associated with decreased intelligence. Since then, several large prospective studies, measuring exposure and outcome sequentially from the in utero environment onward, have generally confirmed and expanded these results. Dr. Kaufman's critique of the literature raises important methodological and inferential points with implications for both future research and policy. Below, we summarize and address his concerns in relation

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* Corresponding author.

to: measurement of known confounders and covariates, measurement of unknown confounders and covariates, statistical model building, reverse causality, and quality control.

1. Measurement of known confounders/covariates

Variables that are both associated with the putative exposure and causally related to the outcome are considered possible confounders and need to be controlled in any statistical analysis. Because childhood intelligence has multiple contributors, there are many potential confounders of the lead–intelligence association. Nondifferential measurement of the potential confounders can result in a biased estimate of the exposure–outcome association; but this bias can be either towards or away from the null, depending on the relationships of the confounder to exposure and to outcome. Dr. Kaufman expresses concern over the measurement of several possible confounders: parenting skill, parental intelligence, and maternal smoking during pregnancy, all of which have been associated with childhood intelligence in numerous studies.

1.1. Parenting

The constructs of parenting skill and quality of the child-rearing environment are not well defined. Indeed, the examples that Dr. Kaufman cites, notably those of length of breast-feeding, maternal alcoholism, and divorce, are easy to measure in the field but tap only potentially narrow dimensions of the conceptual framework of child rearing. Parent–child communication is likely a more meaningful dimension but is neither easily nor well measured in any instrument. Thus, the problem of measuring these constructs is not unique to the lead literature, but prevails in the general area of child development research.

Most researchers in this area, however, have recognized the necessity of measuring these constructs in as valid and reliable a manner as possible. This can be quite challenging during the course of a large field study. The Home Observation for the Measurement of the Environment (HOME) Scale (Caldwell & Bradley, 1984) is one of the most valid and reliable instruments for measurement of the child-rearing environment. Widely used as a predictor of intelligence and achievement, it is currently the best way to capture these constructs in large-scale epidemiologic studies. Thus, this instrument has been used in several of the lead-IQ studies. Dr. Kaufman raises several concerns regarding the HOME, which we address below.

1.1.1. There is no way to check a parent's veracity on the HOME

This is not entirely correct. In fact, many HOME items are scored on the basis of direct observation, not parent interview. As examples, in the course of the home visit, the HOME observer scores materials available in the home (books, puzzles, musical instruments); the observer scores whether or not the parent reacts positively to praise of the child; and whether or not the parent responds to the child's interruptions. In fact, one of the great advantages of the HOME is that it incorporates these observational items, going beyond traditional direct questionnaire or paper-and-pencil measures. Data support the candidness of parents in HOME interviews, since parents sometimes acknowledge undesirable child-rearing practices (e.g.,