Consortium Linking Academic and Regulatory Insights on Bisphenol A Toxicity (CLARITY-BPA) Program

Integration Report Preparation Update

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NTP Board of Scientific Counselors
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• Bisphenol A and origins of the CLARITY-BPA program
• CLARITY-BPA key components
• CLARITY-BPA “core study” peer review and report conclusions
• Academic “investigational” arm, laboratories, endpoints, and publications to date
• Objectives of the integration report(s)
• Elements of systematic review applied to the CLARITY-BPA publications
• Components of Integration report(s)
Bisphenol A (BPA)

- Widely used to make polycarbonate plastics and epoxy resins
- Low human exposure (<1 µg/kg body weight/day) primarily from food contact materials
- Considerable debate over risk as an endocrine disruptor
- Guideline rodent studies conducted under Good Laboratory Practices (GLP) show no effects of concern at “low doses”
- Academic hypothesis-driven studies report that BPA induces effects in a variety of model systems at low exposures
- Suggestive findings from human epidemiology studies
- Widespread agreement that there is disagreement on human health significance

• Evaluated available scientific literature for possible effects of BPA on human development and reproduction

• Conclusions:
  
  – **Some concern:** brain, behavior, and prostate gland in fetuses, infants, and children at current exposure levels

  – **Minimal concern:** Developmental toxicity for fetuses, infants and children (effects on mammary gland and early puberty in females), and reproductive toxicity in workers

  – **Negligible concern:** Reproductive toxicity in adult men and women, fetal or neonatal mortality, birth defects, or reduced birth weight and growth
FDA Draft Assessment (2008) concluded the no-observed-adverse-effect-level (NOAEL) was 5,000 µg/kg bw/day for systemic toxicity.

FDA Science Board (2008) recommended further research to address the potential developmental toxicity of BPA:

- “a large rodent study should be considered to address the central question of developmental toxicity of BPA. To this end, the study must be designed;
  1) to meet criteria for acceptance established by the FDA or reasonable criteria applied by the scientific community for study evaluation that FDA should adopt,
  2) to address the endocrine mechanism-based concerns of the scientific community, and
  3) to use endpoints and models validated for the study of endocrine-mediated developmental processes.”

The FDA considers BPA safe at current levels occurring in foods and food packaging based on:

- Progressive series of “cumulative” formal evaluations from 2009-2014
- Ongoing review of scientific evidence (2014-present)
CLARITY-BPA Inception

• Consortium Linking Academic and Regulatory Insights on BPA Toxicity (CLARITY-BPA)

• Developed by NIEHS and FDA in response to the FDA Science Board recommendation

• Elements
  – Address scientific uncertainties about BPA toxicity
  – Use a long-term oral dosing protocol with developmental exposure
  – Include additional endpoints not typically assessed in guideline studies assessing BPA and endocrine hazards
  – Use a common “core” exposure paradigm across all studies, conducted according to GLP with “positive” EE2 control
  – Use a broad dose range (2.5, 25, 250, 2500, 25000 μg/kg bw/day)
• Novel collaborative research model that draws upon the strengths of investigative and applied-regulatory science research

• Consortium of NIEHS-funded academic researchers with federal scientists and regulators
  – NIEHS
    • Division of the National Toxicology Program (DNTP)
    • Division of Extramural Research and Training (DERT)
  – NIEHS-funded academic grantees
  – FDA
    • National Center for Toxicological Research (NCTR)
    • Center for Food Safety and Applied Nutrition (CFSAN)
• NIEHS Funding Opportunity Announcement (2010)
  – Develop a consortium of researchers to work with the NCTR and NTP in the design of a chronic toxicity study of BPA in NCTR-SD rats with *in utero*, and direct gavage exposures to pups from PND 1 through weaning, or two years
  – Proposals solicited for hypothesis-driven mechanistic studies focusing on disease/dysfunction endpoints to add to the chronic study design

• Applicants selected via NIH scientific peer review (2011)
  – Proposed grantee projects subsequently assessed for technical feasibility by NIEHS and NCTR

• Final Core Study design developed and agreed upon by CLARITY-BPA consortium members (2012)
• “Core Study” 2-year chronic study conducted under GLP at FDA/NCTR
  – Designed in accordance with accepted guidelines for assessing chronic toxicity and carcinogenicity
  – Draft report peer reviewed April, final Report released September 2018

• “Grantee Studies”
  – 14 Academic investigators selected from applications
  – Focus on a range of molecular, structural, and functional endpoints not usually assessed in guideline-compliant GLP studies
  – Used siblings born to Core Study females and raised in the same conditions and exposed to the same doses as for the Core Study

• “Integration Report”
  – Interpretative integration of findings from both the Core Study and the academic investigational studies
• Scientific oversight
  – Steering committee: Representatives from NTP, NIEHS, NCTR, CFSAN, and researchers from the grantee institutions
  – External scientific panel

• Grantee data management
  – Grantees were blinded to the doses of BPA that the animals received
  – All data deposited directly into NTP’s Chemical Effects in Biological Systems (CEBS) database
    • https://ntp.niehs.nih.gov/go/datasearch
  – Decoding team (NIEHS/NCTR) ensured all data collected and missing data explanations were provided prior to decoding and sending decoded data to grantees
“Core Study” Peer Review

• Peer review meeting - April 26, 2018 at NIEHS
  – Six member panel chaired by Dr. David Dorman, NCSU
  – Robust discussion
  – Narrative conclusions rather than “levels of evidence”
  – Revised final report issued as part of the NTP Research Report series

• NTP Research Report on the CLARITY-BPA Core Study: A Perinatal and Chronic Extended-Dose Range Study of Bisphenol A in Rats, NTP RR 9, September 2018
In conclusion,… statistical differences between BPA treatment groups, particularly below 25,000 μg/kg bw/day, and the vehicle control group detected by the low-stringency statistical tests applied to histopathology lesions, were not dose responsive, sometimes occurring in only one low or intermediate dose group, and did not demonstrate a clear pattern of consistent responses within or across organs within the stop- and continuous-dose arms and sacrifice times.

In contrast, the high EE2-dose elicited several estrogenic effects in females in a clearly interpretable and biologically plausible manner.

Several observations at 25,000 μg BPA/kg bw/day may be treatment related, including effects in the female reproductive tract (ovary, uterus, and vagina) and in the male pituitary.
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<th>Principal Investigator</th>
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<th>Health Endpoint</th>
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<td>Scott Belcher</td>
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<td>Nira Ben-Jonathan</td>
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<td>Obesity/adipose tissue</td>
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<td>Andrew Greenberg</td>
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<td>Heather Patisaul</td>
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<td>Gail Prins</td>
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<td>Cheryl Rosenfeld</td>
<td>University of Missouri</td>
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<td>Ana Soto</td>
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<td>Frederick vom Saal</td>
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<td>Male urogenital abnormalities</td>
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<tr>
<td>Thomas Zoeller</td>
<td>University of Massachusetts</td>
<td>Thyroid and brain anatomy</td>
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Next Steps-First Objective

• **Collate** information from core studies with academic investigational studies published or (pending publication) for each organ system
  
  – Brain/behavior 6
  – Cardiac 1
  – Diabetes (pancreas, liver) (1)
  – Immune 2
  – Mammary (1)
  – Ovary 1
  – Prostate/penis 1 (2)
  – Testis/sperm 1
  – Thyroid (1)
  – Uterus (1)

• **Synthesize** findings for endpoints using elements of systematic review

• **Develop** consensus confidence statements for association of health effects with BPA exposures and for evidence of non-monotonic dose response
Second Objective

• “While the study is expected to contribute to our understanding of potential effects of BPA, it also has ramifications beyond this specific focus.” Schug et al (2013)
  
  – “By drawing upon the strengths of academic and regulatory expertise and research approaches, CLARITY-BPA represents a potential new model for filling knowledge gaps, enhancing quality control, informing chemical risk assessment, and identifying new methods or endpoints for regulatory hazard assessments.”

• Compare findings and methods from the core and academic CLARITY-BPA consortium studies with prior published studies on BPA by participants in the consortium, using elements of systematic review.

• Identify technologies or enhanced endpoint measures that may improve our capacity to detect endocrine-related effects in guideline studies.

• Discuss strengths and limitations of the CLARITY-BPA approach to an academic-regulatory partnership.
Systematic Review - What is it and why use it?

• Systematic reviews, pioneered in the clinical field, provide a transparent, methodologically rigorous and reproducible means of summarizing the available evidence on a precisely framed research question.

• Systematic-review methodologies provide objectivity and transparency to the process of collecting and synthesizing scientific evidence in reaching conclusions on specific research questions.

• The product of a systematic review can then be used to inform decisions, reach conclusions, or identify research needs.
Systematic Review Process

- Problem formulation and protocol development
- Comprehensive literature search
- Select relevant studies and extract data
- Assess individual study quality/risk of bias*/utility
- Rate confidence in the body of evidence

*Risk of bias is defined as a measure of whether features of the design, conduct or analysis of a study may cause systematic error in the study’s results

Evidence Integration

- Process for developing hazard conclusions by integrating evidence from human and experimental animal studies with consideration of the degree of support from mechanistic data

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No plans for evidence integration steps

Evidence Integration

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Organization of Reports

- Introduction – purpose, methods
- Results of the CLARITY-BPA study
- Consensus conclusions of the CLARITY-BPA consortium
- Assess prior published studies on BPA from laboratories participating in CLARITY-BPA
- Recommend changes to “guideline” studies for endocrine active agents if appropriate
- Determine strengths and limitations of the linkage of academic and guideline studies under the CLARITY-BPA design
- Suggest future ways to integrate academic and guideline compliant studies of endocrine active agents
- Appendices
  - Systematic review protocols for each endpoint evaluated
  - Study quality/risk of bias evaluations
• Published study evaluations (underway)
• Waiting on final publications
• Consortium review and consensus conclusions (Spring 2019)
• Public Peer Review (Summer 2019)
• NCTR staff: Barry Delclos, Luisa Camacho, and many others

• Academic laboratories: Scott Belcher, Nira Ben-Jonathan, Kim Boekelheide, Jodi Flaws, Nestor Gonzalez-Cadavid, Andrew Greenberg, Shuk-mei Ho, Norbert Kaminski, Heather Patisaul, Gail Prins, Cheryl Rosenfeld, Ana Soto, Frederick vom Saal, and Thomas Zoeller

• NTP/NIEHS Nigel Walker, Mary Wolfe, and many others

• DERT/NIEHS Thad Schug, Jerry Heindel

• The Chemical Effects in Biological Systems (CEBS) team

• Integration report preparation team: Kembra Howdeshell, Andrew Rooney, Brandy Beverly, Retha Newbold, Vickie Walker, and ICF contract support
Questions?