TRAVELING WITH TOXICS

Flame Retardants & Other Chemicals in Children's Car Seats

HEALTHY STUFF
Researching toxic chemicals in everyday products

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HealthyStuff.org,
A Project of the Ecology Center

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ECOLOGY CENTER

The Ecology Center is a Michigan-based nonprofit environmental organization that works for a safe and healthy environment where people live, work and play.

HealthyStuff.org, which researches and analyzes hazardous chemicals in everyday products, is a project of the Ecology Center.

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EXECUTIVE SUMMARY

THE ECOLOGY CENTER HAS TESTED CHILD CAR SEATS PERIODICALLY FOR TEN YEARS, tracking changes in chemical additives. Car seats are a required product in which babies and children typically spend hours per day. The flame retardant (FR) chemicals historically used in car seats are known to be carcinogens, hormone disruptors, and developmental toxicants. Exposure occurs through contamination of air and dust. Safer alternatives are available, and while our testing has shown trends away from the worst chemicals, companies can do much better.

In fact, one company has answered our longtime call. Uppababy unveiled a new seat for 2017 specially designed to contain no added FRs. To our knowledge, the MESA Henry will be the first flame retardant-free car seat on the market, and its story and test results are included as a sidebar in this report.

In this study, we analyzed flame retardants and other chemicals in fifteen infant and toddler car seats purchased in 2016, including two from the United Kingdom. The brands are BabyTrend, Britax, Chicco, Clek, Cosco, Diono, Evenflo, Graco (two models), Joie, Maxi-Cosi, Nuna, Orbit, Recaro, and Safety 1st. The seats represent a broad price range and about half were brands also tested by our team in 2014.

Three different analytical techniques were used: X-ray fluorescence, infrared spectroscopy, and gas chromatography with mass spectrometry.

It is to be understood throughout this report that 1) vehicle interiors are chemically flame-retarded to begin with and 2) that car seats provide vital crash protection, and children should always ride in a properly installed seat, regardless of chemical hazard.

Overall findings

- Flame retardants were found in all 15 car seats, and for the first time were found to be in widespread use in the fabrics of car seats.
- Most car seats still contain brominated flame retardants. Many companies are also using phosphorus-based flame retardants, including some not previously known to be used in car seats.
- In 2017 a car seat marketed as free of flame retardants will be on the market produced by UPPAbaby. Our testing confirmed their claim.
- Manufacturers have stopped using some flame retardants with known hazards, but the effects of the many of the substitutes are unknown.

Change is happening, yet all seats still contained flame retardant chemicals

Our study shows that the car seat industry continues to change its approach to meeting flammability standards. The industry continues to shift away from halogenated FRs and to choose materials that allow flammability standards to be met without hazardous chemicals. Currently, however, chemical flame retardants are still in widespread use in car seats. Highlights of the report:

- For the first time no car seat contained chlorinated tris or other related FRs. This is a notable improvement compared to models from 2014, when the carcinogen chlorinated tris was found in 3 of 15 seats. Two of those brands, BabyTrend and Orbit, were retested for this report.
- We detected FRs in all tested car seats (not including UPPAbaby), including the two seats purchased in England, Graco Milestone and Joie Stages.
- Also for the first time since we started testing in 2006, no lead was detected in any seats. No other hazardous metals such as arsenic were detected, either, with the exception of antimony, which is likely present as a flame retardant synergist.
- Unfortunately, brominated FRs remain in frequent use, this year detected in 13 of the 15 seats (87%). This is concerning, as brominated chemicals are typically persistent, bioaccumulative, and often toxic.
- Two seats did not contain any brominated FRs (Maxi Cosi and Britax) and two seats contained brominated chemicals only in smaller components such as warning labels or Velcro, not in fabrics or foams (Clek and Orbit).
- Phosphorus-based, halogen-free FRs were detected in all 15 seats. Eliminating halogens is important, but even halogen-free FRs must be thoroughly studied for health hazards. Some of the phosphorus FRs found in 2016 seats may pose a lower hazard, but we found health-related data to be lacking.

Materials matter: Both fabrics and foams are frequently treated with flame retardants

To our knowledge, this study represents the most detailed assessment to date of different material in car seats. Our analysis illustrates the importance of studying components other than polyurethane foams in upholstered products.

- **Fabrics** have been studied a lot less than foams, so this year we tested over 160 fabric samples and found nearly one-third (32%) contained at least one FR.
- A quarter (25%) of fabric samples contained a brominated FR.
- 16% of fabric samples contained phosphorus flame retardants (PFRs), including cyclic phosphonate esters and possibly ammonium polyphosphate. Although our study is the first, to our knowledge, to detect these FRs in car seat fabrics, these FRs have been available for many years. They are marketed as safer alternatives.
- 73% of car seats had **polyurethane foam** containing phosphorus-based flame retardants. This likely represents an increase in the use of PFRs, as 50% of seats in 2014 contained PFRs. Of PFRs found in polyurethane foam, the majority were tris(butoxyethyl)phosphate, a possibly safer alternative than triphenyl phosphate.
- Usage of triphenyl phosphate in the polyurethane foams of car seats appeared to decline compared to 2014.
- With one exception (part of a plastic frame), **hard plastic parts and belt straps** did not contain detectable FRs.
- **Brominated FRs** were found almost exclusively in **polyester textiles** (26%) and in **rigid foams** (43%), not in soft polyurethane foam. This finding is similar to the 2014 findings. Specific BFRs detected were 1) in fabrics: brominated styrenes, tris(bromopropyl) isocyanurates, and unidentified BFR; and 2) in polystyrene foam: brominated cyclododecanes (likely hexabromocyclododecane).

Flame-retardant free car seats are within reach

As long as car seats are subject to the federal flame standard for cars, the best approach is to redesign car seats so that hazardous chemicals are not necessary. Our studies have shown manufacturers decreasing the use of chlorinated and brominated FRs in foams and increasing the use of halogen-free FRs. This is a step in the right direction. However, brominated FRs remain frequently used in car seat fabrics, and some of the halogen-free FRs such as triaryl phosphates pose health concerns as well. We now encourage companies to follow UPPAbaby's lead by making a few material changes, such as using naturally fire-resistant wool, to avoid adding FRs.

Flammability regulations should be modified

While car seats can be designed to pass the flame test without chemical additives, this approach costs more money. Affordable car seats should not come with a chemical exposure cost.

Policy makers should consider exempting child car seats from the federal flammability standard FMVSS 302. Despite 44 years of this U.S. regulation, The National Highway Traffic Safety Administration can provide no evidence suggesting that the rule protects children in vehicle fires. FMVSS 302 has resulted in car seat makers adding thousands of pounds of chemical flame retardants to products that infants and children are in close contact with every day.

IMPORTANT NOTE

PARENTS AND CAREGIVERS SHOULD ALWAYS PROPERLY INSTALL AND USE A CAR SEAT appropriate for a child's age and size, regardless of concerns about chemical hazards in the seat. This applies to older children as well as infants. Vehicle child restraint systems are essential for protecting children during car accidents. Between 1975 and 2014, as car seat usage skyrocketed, the number of infants dying in vehicle crashes dropped by 80%. The decline in deaths of children ages 1-3 was 73%, and ages 4-8 was 53%.[1]

Parents should also be aware that the inside parts of a car, including the built-in seats, contain significant flame retardant additives.

INTRODUCTION

THE ECOLOGY CENTER HAS MEASURED AND REPORTED on hazardous chemicals used in children's car seats since 2006. At the same time, we have worked to advance needed changes in government and corporate chemical policies. Our work has led several car seat companies to eliminate some of the worst chemical hazards from their products. In fact, one company, UPPAbaby, has announced they will produce a chemical flame retardant-free car seat in 2017.

Here, we present a new study of 15 infant and toddler car seats purchased in the past eight months, including two from the United Kingdom. We examined the seats for heavy metals as well as flame retardant (FR) chemicals. In addition to analyzing foam, which has been the target of significant research, we analyzed a large number of fabric (textile) samples from the seats. The FR chemicals used in fabrics are in many cases different than those used in foam.

Our team has screened 392 car seats in the past decade, using more sophisticated test methods over time. **Table 1** lists the number of seats tested in each year. Prior to 2014, we screened for two broad chemical classes of FRs, brominated and chlorinated, without identifying specific compounds. Starting in 2014, we added additional laboratory analysis to identify the FR chemicals.

Purpose and hazards of flame retardant chemicals

In 1971, the U.S. agency responsible for traffic safety, National Highway Traffic Safety Administration (NHTSA), wrote a rule intended to protect vehicle occupants from fires. The rule, FMVSS 302, required that a "material shall not burn, nor transmit a flame front across its surface at a rate of more than four inches per minute." It was written particularly to guard against cigarette fires.

The materials inside a car can ignite and burn quickly because they are made from synthetic polymers. FMVSS 302 does not require the use of chemical flame retardants. However, to comply with the rule, automakers began treating interior parts, such as seats, with chemical flame retardants. Car seats for infants and children must meet the flammability standard as well, so manufacturers likewise treat the foams and fabrics of car seats. Chemical flame retardants have been marketed by the chemical industry as an easy way to comply with the law.

Fast forward a few decades, and these FR chemicals are found everywhere scientists look: in the blood of newborns and adults, in breast milk, in Arctic air, in polar bears, in the waters of the Great Lakes. Many FRs are highly persistent—they don't break down easily. (See Table 9.)

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TABLE 1 **History of Ecology Center car seat studies**

Year of Study	Number of car seats tested	Analytes (what we tested for)
2006	131	Bromine, chlorine, heavy metals
2008	59	Bromine, chlorine, heavy metals
2011	153	Bromine, chlorine, heavy metals
2013	18	Bromine, chlorine, heavy metals
2014 (pub. 2015)	15	Multiple specific FRs, metals, bromine, chlorine, phosphorus.
2016	15	Multiple specific FRs, metals, bromine, chlorine, phosphorus.

Chemical FRs also pose a hazard to our health. Some of the most widely used flame retardants since the 1970s are carcinogens, causing cancer in multiple organs in laboratory animals. Some disrupt hormones and reproduction and may contribute to obesity. Effects on fetal and child development and on the immune system have also been reported. [2-4]

Halogen-free FRs such as phosphate-based flame retardants (PFRs) have increased in popularity as alternatives to the halogenated products. However, some PFRs have been found to be toxic and bioaccumulative; many or most have not yet been adequately assessed.[5-7]

Flame retardants can become acutely hazardous when they burn.[8] When foam containing pentaBDE (a brominated FR) burned in one study, for example, it produced twice as much smoke, seven times as much carbon monoxide, and 70 times as much soot as foam without flame retardants.[9] It was also found that a typical foam containing pentaBDE provided only a three-second delay in ignition compared to the untreated foam.

In addition to smoke, soot, and carbon monoxide, increased levels of furans and dioxins are emitted when FR-containing materials burn. Furans and dioxins are known to cause cancer. Firefighters have higher rates of cancer than the general population, and their exposure to FRs and their toxic combustion products may be a contributing factor.[10]

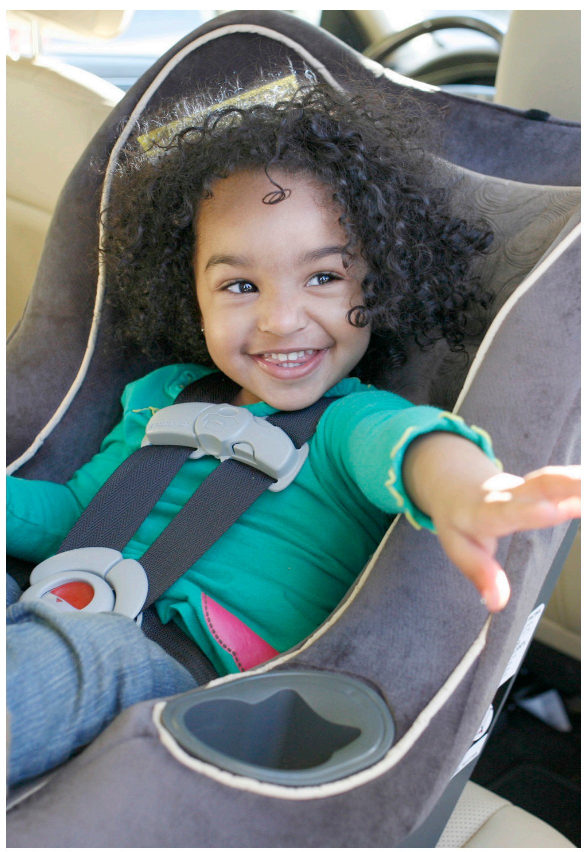
Are flame retardants in car seats necessary?

Has the requirement for car seats to comply with FMVSS 302 saved lives and prevented injuries? NHTSA cannot say. The agency has never evaluated the effectiveness of the rule as it applies to car seats due to lack of relevant data.[11]

As part of a months-long investigation into flame retardant chemicals in car seats, San Francisco CBS News reporter Julie Watts also found a surprising lack of data: "In response to our investigation, NHTSA admitted that it has never evaluated the effectiveness of the federal motor vehicle standard in children's car seats. The agency also said it was unaware of any records, data or studies that indicate the current flammability standard is relevant or provides any fire safety benefit in a child's car seat.

"In fact, we reached out to more than a dozen government agencies and industry groups, and no one could provide any evidence."[12]

In June 2015, the Ecology Center called for NHTSA to review FMVSS 302 and considers it critical that the standards be modernized.



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In response to these concerns, Congressman Jared Huffman (D-San Rafael, California) introduced federal legislation (HR 5359) in May 2016 to modernize car flammability regulations.[13] Huffman's legislation would update car seat regulations by:

"Requiring NHTSA to update its flammability test for children's car seats from an 'open flame' to a 'smolder' test. California Governor Jerry Brown has approved a similar shift for furniture sold in the state because of concerns regarding toxic flame retardant chemicals. This smolder test is a more appropriate standard for the types of fire hazard risks actually present in automobile crashes, and will ensure that the use of arbitrary and inappropriate standards do not force manufacturers to apply dangerous chemicals unnecessarily; and

"Ensuring that the Environmental Protection Agency is consulted regarding the health effects and risks associated with the chemical flame retardants in question to determine an appropriate standard for use."

"Car seats are designed to protect infants and children when they ride in a car, and they do that job admirably," – Rep. Jared Huffman (D-San Rafael, California).

"Unfortunately, they also unnecessarily expose children to harmful chemicals for no apparent safety benefit. Just as California has modernized standards to reduce exposure to flame retardant chemicals in furniture, my legislation will reduce children's needless exposure to toxic chemicals, while still ensuring the highest level of health and safety protections."

In July 2016, NHTSA commenced a review of the appropriateness of applying FMVSS 302 to car seats and the general need for and effectiveness of the standard for the entire vehicle. NHTSA's response to questions from congressional representatives about the review process is included in the appendix of this report.

In addition to calling for a federal review of the standard as it applies to car seats, in June 2015, the Ecology Center again called for car seat makers to begin producing seats without added FRs by carefully choosing materials to meet flammability standards.

This year, UPPAbaby unveiled a new seat for 2017 specially designed to contain no added FRs. To our knowledge, the Mesa Henry will be the first FR-free car seat on the market, and its story and test results are included on page 7 of this report.

While an advance, pre-market version of MESA Henry was evaluated by HealthyStuff.org in October 2016, it is not included in the main study of 15 seats purchased in 2016 because the Henry is not currently available (the expected retail delivery date is spring 2017) and was not analyzed with GC/MS as were the rest of the car seats in this study.

BOX 1 Fire safe & flame retardant-free

This fall, the company UPPAbaby revealed the “Henry,” a new infant car seat in their “Mesa” line. The product has several features to make life easier for parents. In one regard, however, the philosophy of “less is more” prevails. The Henry leaves out chemical flame retardants in favor of a wool blend put in place to meet flame retardancy regulations.

Wool is well known to have fire-resistant properties. Organic bedding mattress makers have used wool to avoid chemical flame retardants for years, and have remained compliant with safety standards. UPPAbaby’s Mesa Henry, however, is the first car seat to be manufactured with wool for that purpose. The Henry seat also uses expanded polypropylene (EPP) foam as the impact-absorbing foam because EPP does not require additional FRs.

Our researchers at the Ecology Center tested a pre-market 2017 UPPAbaby Henry car seat using XRF and FTIR. We also reviewed independent third-party lab results provided by the company. In addition, polyurethane foam from the Henry seat was tested by Duke University’s foam testing program with GC/MS. All three labs found no evidence of FR chemicals.

Our FTIR testing, however, detected melamine in the adhesive gluing fabric to polyurethane foam. We were unable to find information on the potential migration of and human exposure to melamine from an adhesive. We expect and encourage UPPAbaby to substitute an adhesive that contains no chemicals of concern.

UPPAbaby is a family-owned business based in Hingham, Massachusetts. They design and produce high end strollers and infant car seats. The FR-free design of the Henry adds $50 to the normal $300 price tag. Orders are already streaming in.

We hope this design strategy will catch on with manufacturers of car seats in all price ranges. FR-free car seats should be affordable to all. The flame retardant free Henry will be available when the 2017 car seat models come out in spring 2017.

XRF results for the Henry are summarized in **Table 2**. The measured concentrations of antimony, bromine, and chlorine are below levels associated with the use of flame retardants. Several components have antimony between 100 and 200 ppm, which is a typical range for antimony left over from use as a polymer catalyst. The levels of lead and other metals are typical of background levels commonly seen in polymers.

TABLE 2 **UPPAbaby Mesa Henry XRF screening results. Error ranges associated with each measurement are available in our database at healthystuff.org.**

Component	Sub-component	Antimony	Bromine	Chlorine	Lead	Phosphorus
		XRF, ppm	XRF, ppm	XRF, ppm	XRF, ppm	XRF, ppm
Frame	EPP foam	196	2	383	6	0
	Plastic	0	0	0	0	0
Harness	Strap	194	4	0	2	0
Upholstery	PU foam	188	4	508	8	0
	Canopy fabric	82	184	369	2	0
	Exterior wool blend fabric	0	2	0	3	0
	Interior white fabric	0	2	365	2	0
	Warning label	0	2	0	4	0

EXPERIMENTAL METHODS

FIFTEEN SEAT MODELS, REPRESENTING FOURTEEN POPULAR BRANDS, were purchased at retail stores in Michigan or ordered online. Some brands were chosen with the aim of comparing to previous study results, while others had not been tested before. Of the 15 tested seats, 5 were infant car seats, 9 were convertible infant-to-booster seats and one was a toddler seat. The details of the seats are displayed in **Table 4**. Thirteen seats were manufactured in 2016 and two in the latter half of 2015.

Sample collection and preparation

Each seat was cut apart to isolate pieces of foams, fabrics, and plastics. We attempted to sample the distinct materials in each seat. Each sample was first analyzed by an X-ray Fluorescence spectrometer, described below. This resulted in a total of 387 material samples analyzed from the 15 seats.

The parts were categorized into three major component groups: Base/Frame, Harness, and Upholstery, each with subcomponent categories, as listed in **Table 3**. Some of the 387 subcomponent samples were tested twice to verify repeatability.

X-Ray Fluorescence (XRF)

High Definition X-ray Fluorescence (HD XRF) is an elemental analysis technique with greater sensitivity than standard XRF. Our instrument from XOS uses monochromatic excitation energies of 7, 17, and 33 keV. The spot size is one millimeter. Elements heavier than aluminum are measurable. We abbreviate HD XRF as "XRF" in this report.

Detection limits are in the low parts-per-million (ppm) or sub-ppm range for all elements of interest in this study except chlorine and phosphorus. For chlorine we consider results above 1,000 ppm to be quantitative. For phosphorus the limit of detection is roughly 5,000 ppm and we visually inspect spectra for the presence of a peak at 2.01 keV. From the elemental composition, we learn whether heavy metals are present and can infer the likely presence

DIAGRAM 1 **Car seat components**

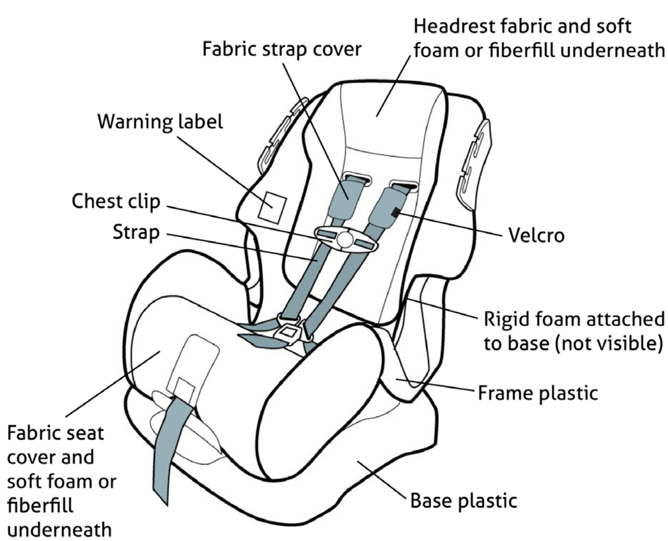

TABLE 3 **List of components that were isolated (if present) and tested from each seat**

Major Component	Sub-component categories
Base/Frame	Base plastic
	Cup holder
	Frame plastic
	Handle
	Rigid foam
Harness	Clip
	Strap
Upholstery	Fiberfill
	Soft polyurethane foam (PU)
	Textiles
	Velcro

TABLE 4 **Car seats in the study**

Brand Name	Model	Design	Type	Manufacture Date	Retail Country	Retail Cost (USD)
Baby Trend	Secure Snap Gear 32 Infant Car Seat	Astro	Infant	Mar. 2016	U.S.	120
Britax	Marathon ClickTight Covertible Car Seat	Vibe	Convertible	Jun. 2016	U.S.	290
Chicco	KeyFit 30 Infant Car Seat	Legend	Infant	Jan. 2016	U.S.	200
Clek	Foonf Convertible Car Seat	Capri	Convertible	May 2016	U.S.	450
Cosco	Scenera NEXT Convertible Car Seat	Otto	Convertible	Feb. 2016	U.S.	46
Diono	Rainier Convertible + Booster Car Seat	Glacier	Convertible	Apr. 2016	U.S.	360
Evenflo	Nurture Infant Car Seat	Sabrina	Infant	Mar. 2016	U.S.	68
Graco	MyRide 65 Convertible Car Seat	Chalk	Convertible	Feb. 2016	U.S.	107
Graco	Milestone Group 0-1-2-3 Car Seat	Aluminum	Convertible	Jan. 2016	U.K.	186
Joie	Stages Group 0+, 1 & 2 Car Seat	Caviar	Convertible	Feb. 2016	U.K.	186
Maxi-Cosi	Pria 70 Convertible Car Seat	Blue Base	Infant	Mar. 2016	U.S.	250
Nuna	Pipa Infant Car Seat with Base	Scarlet	Infant	Jun. 2015	U.S.	300
Orbit Baby	G3 Toddler Convertible Car Seat	Black	Toddler	Oct. 2015	U.S.	380
Recaro	ProRide Convertible Car Seat	Aspen	Convertible	May 2016	U.S.	240
Safety 1st	Grow and Go 3-in-1 Convertible Car Seat	Boulevard	Convertible	May 2016	U.S.	170

of flame retardants.

While XRF testing cannot identify molecular structure of organic chemicals, detecting bromine greater than 400 ppm and chlorine greater than 3,500 ppm has been successfully used to infer the presence of halogenated flame retardants, depending on the sample matrix.[14-16] We also demonstrated that phosphorus detected by XRF in car seat fabrics and foams can be an indicator of PFRs.[16]

Fourier Transform Infrared Spectroscopy (FTIR)

Samples with elevated bromine and/or phosphorus according to XRF were further analyzed using a Nicolet iS5 FTIR spectrometer with an attenuated total reflection (ATR) accessory. First, samples were cut into small pieces and extracted in a glass vial with isopropyl alcohol. After at least 24 hours, extracts were analyzed by FTIR. We used commercial FTIR libraries to identify extracted chemicals. Phosphorus-based FRs present in these samples were identifiable by this method, while the bromine-containing FRs were not. The resulting data was used in conjunction with the XRF and GC/MS data to help identify specific FR chemicals. FTIR was also used to identify polymer type.

Gas Chromatography/Mass Spectrometry (GC/MS)

A subset of 43 samples was chosen for a more sensitive GC/MS analysis. From each seat, at least one sample each of soft polyurethane foam, rigid foam, and fabric were taken, when present. Scissors and knives were wet-cleaned with isopropyl alcohol before and after each cut. Cut samples were immediately placed into individual polyethylene bags to avoid cross-contamination. Three to five grams of material were sent to STAT Analysis in Chicago, Illinois for analysis.

FRs in each sample were extracted following EPA method 3545 for accelerated solvent extraction, then analyzed by GC/MS following EPA method 8270C for semi-volatile organic compounds.

Authentic standards were available for the following FR chemicals: TDCPP, TCPP, TCEP, TDBPP, TEP, TPP, TBEP, TBPH, and TBPP. (See Box 1 for acronyms.) For TDCPP, TCPP, TCEP, TDBPP, a five point calibration curve was used for identification and quantitation. For TEP, TPP, TBEP, TBPH, and TBPP, a single point calibration curve was used.

The lower limit of detection for this technique depended on the sample mass and matrix, ranging from 32 to 110 ppm (0.0032% to 0.0110% by mass).

For other FR chemicals detected in the samples, for which authentic standards were not available, qualitative identification was made by comparison with mass spectra in a NIST library. These GC/MS identifications were further informed by XRF measurement of bromine and/or phosphorus, as well as by FTIR spectra of extracts from the samples. We have high confidence in the accuracy of these qualitative results. For those chemicals that could be extracted in our lab, the GC/MS identifications agreed with the FTIR identifications based on their respective libraries.[16] Future work should, however, verify these chemicals in car seats using authentic standards.

The list of analytes GC/MS could detect in this study is given in **Table 5**. Many of these were not detected in any of the tested car seat components.

Combined Instrument Analysis

Each of the three instrumental techniques described above provided different pieces of evidence to help us determine the identity of chemicals in each sample. XRF provided the base screening for key elements phosphorus, bromine, and chlorine. We have established that XRF detection of these elements is a reasonable indicator of the presence (not the quantified concentration) of FRs in foams and fabrics of car seats.[16]

FTIR provided qualitative detection of some but not all FRs. GC/MS provided either quantification or nonquantitative detection of some FRs. GC/MS could identify some FRs that FTIR could not, and vice versa. Therefore, some of our FR and likely FR identifications are based on all three methods, some are XRF and FTIR only, some are XRF and GC/MS only, and some are XRF only.

TABLE 5 **FR chemicals our methods were capable of detecting in this study.**
(Many of these were not detected in any of the tested seats.)

Abbreviation	FR chemical name	CAS #	Analysis type	Authentic standard used for GC/MS?**
BrPS	Brominated polystyrenes	57137-10-7	GC/MS	no
Cyclic phos. ester	Cyclic phosphonate esters, similar to Amgard CU or 1045	41203-81-0, 42595-45-9	FTIR, GC/MS	no
HBCD	Hexabromocyclododecane*	25637-99-4	GC/MS	no
HEEHP-TEBP	2-(2-hydroxyethoxy)ethyl 2-hydroxypropyl 3,4,5,6-tetrabromophthalate	20566-35-2	GC/MS	no
ITP or IPTPP	Isopropylated triaryl phosphates (including isopropylated triphenyl phosphate)	68937-41-7	GC/MS	no
TBBPA	2,2′,6,6′-Tetrabromobisphenol A	79-94-7	GC/MS	no
TBC	Tris(2,3-dibromopropyl)isocyanurate	52434-90-9	GC/MS	no
TBE	1,2-bis(2,4,6-tribromophenoxy)ethane	37853-59-1	GC/MS	no
TBEP	Tris(2-butoxyethyl)phosphate	78-51-3	FTIR, GC/MS	yes
TBPH	Bis-(2-ethylhexyl)tetrabromophthalate	26040-51-7	GC/MS	yes
TBPP	Tris (4-butylphenyl) phosphate	78-33-1	GC/MS	no
TCEP	Tris(2-chloroethyl) phosphate	115-96-8	FTIR, GC/MS	yes
TCP	Tricresyl phosphate isomers	1330-78-5	GC/MS	no
TCPP	Tris(2-chloropropyl) phosphate	13674-84-5	FTIR, GC/MS	yes
TDBPP	Tris(2,3-dibromo-1-propyl) phosphate	68112-30-1	GC/MS	yes
TDCPP	Tris(1,3-dichloro-2-propyl) phosphate	13674-87-8	FTIR, GC/MS	yes
TEP	Triethyl phosphate	78-40-0	GC/MS	yes
TPP	Triphenyl phosphate	115-86-6	FTIR, GC/MS	yes

* GC/MS in this study identified brominated cyclododecanes without determining the degree of bromination. Based on previous work and the literature, we expect those detections are HBCD.
** For chemicals without a standard available, a NIST mass spectral library was used for GC/MS detections. Only chemicals with a standard had concentrations quantified. An infrared spectral library from Thermo Scientific was used for FTIR detections.

RESULTS & DISCUSSION

Heavy Metals

WE HAVE DOCUMENTED A SIGNIFICANT REDUCTION in contamination of car seats with heavy metals (lead, arsenic, and cadmium) over the past decade. These metals were likely unintended contaminants. Quality control appears to have improved, as this is our first study in which no heavy metals other than antimony were detected in any tested seats. Antimony was detected in 4% of tested fabrics at levels suggesting an antimony based FR synergist.

Comparison to 2014 Seats

Of the 15 seats purchased in 2016, all 15 contained phosphorus chemicals that are likely PFRs. Thirteen contained brominated chemicals that are likely BFRs. (**Table 8** provides detailed results and **Table 9** provides health-related information.)

Table 6 shows changes in FR use over time by comparing the results of PU foam testing from 2014 versus 2016 seats. We included only PU foam in this comparison because fabrics were not comprehensively screened in 2014. The use of BFRs remains very low in PU foam. The use of chlorinated FRs has apparently dropped, which is a beneficial trend. In 2014, two forms of chlorinated tris and TCEP were detected, whereas no known chlorinated FRs were found in the 2016 seats. (However, the Clek blue fabric and the cover on its anti-rebound bar tested high in chlorine by XRF, but no FR was extracted or detected. The source of this chlorine remains undetermined.)

Chemicals used depend on the material

Table 7 summarizes XRF results as a function of material type in the car seats. Four elements are included: Antimony, suggesting inorganic FRs like antimony trioxide; bromine, suggesting BFRs; chlorine, suggesting chlorinated FRs; and phosphorus, suggesting PFRs. XRF numerical results for all seat materials are detailed in Table 10 on page 21.

The three different foam materials—polyurethane (PU), expanded polystyrene (EPS), and expanded polypropylene (EPP)—were determined by visual inspection and by infrared spectroscopy.

A single seat often had multiple different PU foams and fabrics, some with FR additives and some without. The calculations in this table include all samples.

Observations from Table 7 include the following.

- Rigid foam, which is an impact-absorbing foam in a car seat, can be either EPS or EPP. EPP meets automotive fire standards without added flame retardants and as such shows no elements of concern (first row in the table). The same was true in our earlier report.
- EPS, on the other hand, frequently contains bromine--sixty percent of the EPS foams tested in this study. HBCD has historically been common, but polymeric BFRs are reportedly on the rise.[17] According to the EPA, "no nonbrominated flame retardants are known to be compatible in polystyrene manufacturing

TABLE 6 **Comparison of 2016 and 2014 polyurethane foams in car seats**

	Number Tested	PU contains Br>500 ppm	PU contains Cl>3,500	PU contains P>5,000 ppm
2016 seats (current study)	15	1 (7%)	0	11 (73%)
2014 seats (previous study)	14	1 (7%)	4 (29%)	7 (50%)

TABLE 7 **Breakdown by material**

		Samples containing:			
Material	**Number of Samples**	**Antimony >500 ppm**	**Bromine >500 ppm**	**Chlorine >3,500 ppm**	**Phosphorus >5,000 ppm**
EPP rigid foam	5	0	0	0	0
EPS rigid foam	10	0	6 (60%)	0	0
Fiberfill	25	0	0	0	0
Handles or anti-rebound bar	4	0	0	1	0
Hard plastic including cup holders and frames	70	0	1 (1%)	0	0
Harness straps	22	1 (5%)	0	0	0
Plastic chest clips	12	0	0	0	0
Polyurethane foam	49	0	1 (2%)	0	22 (45%)
Textile fabrics	162	6 (4%)	39 (24%)	3 (2%)	24 (15%)
Velcro	21	0	4 (19%)	0	0
Warning labels	5	1 (20%)	2 (40%)	0	2 (40%)

and associated flame tests."[18] We encourage car seat makers to swap EPS foam with EPP to avoid BFRs. Although the exposure potential is expected to be lower for a polymeric BFR, they are persistent, and the long-term fate of these chemicals in the environment has not been studied.[18]

- Fiberfill is made of polyester and did not appear to contain any FRs.
- The hard plastics used for car seat frames and cup holders contained no elements of concern, with one exception: blue plastic in the Nuna seat contained bromine.
- Harness straps and plastic chest clips contained almost no elements of concern.
- Polyurethane foam, which is used in the seat upholstery for cushioning, contained no BFRs or CFRs with only one likely exception (one foam had elevated bromine).
- Fabrics, or textiles, as a group contained the widest variety of FRs. Bromine and phosphorus were the most common relevant elements detected. Textiles will be discussed in more detail after introducing the GC/MS and FTIR results.
- Velcro and warning labels sewed on the seats were unexpected sources of bromine, as well as antimony and phosphorus.
- Elevated antimony, from about 1,000 to 7,000 ppm, was measured in a number of fabrics and foams. This concentration range suggests an antimony-based FR. The high-antimony samples were in some cases accompanied by elevated bromine—a strong indication that a FR synergist such as antimony trioxide was used with a BFR.
- In contrast to our earlier studies, chlorine was not found in a concentration range suggesting FRs in any components with the exception of Clek's fabric and the cover on its anti-rebound bar. Clek states in a private communication that their fabric contains no added FRs of any kind. We did not identify FRs in Clek's fabric using FTIR and GC/MS. The source of chlorine in the fabric remains unidentified.

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Detailed flame retardant results

Table 8 gives the most detailed FR results. It lists the components of each seat (second column) likely to contain FR based on XRF results for antimony, bromine, and phosphorus. Next, specific chemicals are listed. These are based on a combination of GC/MS and FTIR analyses. Likely FRs based on XRF alone are also listed.

The GC/MS method used could not identify all possible FRs. In particular, FRs that are large molecules or are chemically reacted into the polymer matrix, instead of physically blended, are unlikely to be detected. Thus, for several components, we used XRF as a proxy for a nonspecific FR. We list those results as "unidentified brominated (or phosphorus) chemical" with the understanding that these are most likely FRs. One caveat is needed for fabrics with unidentified brominated compounds: There is some possibility these could reflect a brominated azo dye[19] rather than a FR. We urge companies to eliminate halogenated chemicals from children's products.

Based on this composite analysis, none of the 2016 car seats were free of flame retardants. The Britax and Maxi-Cosi models, however, were free of halogenated FRs, which is a good step. As a chemical class, halogenated FRs are typically persistent, bioaccumulative, and toxic, and should be used as little as possible.

Observations from **Table 8** include the following.

- FRs in fabrics have been much less studied than foams, but the present work shows that car seat fabrics are commonly FR-treated. These should be further studied as sources of exposure for infants and children.
- Fabrics as a group contained the widest variety of FRs, including at least three different BFRs and at least four different PFRs. The specific BFRs found in the car seat fabrics were brominated polystyrene, which is used as an additive in fabrics, TBC, and some unknown. The PFRs were cyclic phosphonate esters, TBEP, TEP, and some unknown. Based on their chemical structures,[20] these PFRs may be better choices than BFRs,[21] although health related data are insufficient. (See Table 9 for more information.)
- Rigid EPS foams (and one PU foam) contained BFRs. Two EPS foams tested by GC/MS contained brominated cyclododecanes, which we expect are HBCD; the other two remained unidentified. The unidentified BFRs in EPS foam may be so-called "reactive FRs" that are part of the polymer.[21] EPS and EPP are both used as the impact-absorbing foam in car seats, but only EPS has added FRs.
- The most frequently found FR in PU foam was TBEP, which appears to be a substitute for TPP. Only one foam, in the Diono Ranier, had TPP. This suggests a decline in the use of TPP, which commonly contaminates house dust[22] and is a possible obesogen.[23,24]
- Five seats contained elevated bromine in unexpected components:
  - Fabric warning labels sewed to the seat (52,000 ppm and 21,000 ppm bromine, respectively, in Chicco and Clek). The labels had insufficient sample mass to be tested by GC/MS, so we have not identified the brominated chemicals added.
  - Velcro holding upholstery to frame (10,000 ppm and 1,700 ppm bromine, respectively, in Orbit and Diono). TBBPA was detected in an Orbit Velcro sample. Velcro from the Diono seat had insufficient sample mass to be tested by GC/MS.
  - Hard frame plastic (1,033 ppm bromine in blue nylon plastic in the Nuna seat). This plastic was not tested by GC/MS.
  - We question the necessity of adding brominated compounds to these components and urge car seat companies to use only halogen-free materials. Several seats had screen-printed warning labels rather than sewn-on fabric. This may be a way to avoid flame-retarded fabrics.

The possible presence of polymeric FRs, sometimes called "reactive" FRs because they are chemically bound to the polymer matrix, deserves further investigation in a future study.

Finally, we note that FTIR analysis suggested the presence of ammonium polyphosphate in some fabrics and PU foams. This FR is known to be used in fabrics, but the GC/MS method was not capable of identifying it, so we consider this identification tentative and did not include it in Table 8.

TABLE 8 **Results for components analyzed by GC/MS and with XRF indicators.**
Only chemicals detected in at least one seat in the study are included in this table. For a complete list of FR chemicals our methods were capable of detecting, see Table 5. For concentrations of quantifiable FRs, see Table 11 in the Appendix.

Seat	Component	Nonhalogen Organophosphorus					Brominated					Other[5]
		TEP[1]	TPP[1]	TBEP[1]	Cyclic Phos. Ester[2]	Unid'd P[3]	BrPS[4]	HBCD or related[4]	TBC[4]	TBB-PA[4]	Unid'd Br[3]	
BabyTrend - Secure Snap Gear 32	Fabric - blue canopy					🟠						
	Fabric - white										🟠	Antimony[5]
	Fabric - black	🟢		🟢	🟠		🟠					
	PU foam - white			🟢								
Britax - Marathon ClickTight	Fabric - black											
	PU foam - white	🟢		🟢								
Chicco - KeyFit 30	EPS foam - white							🟠				
	PU foam - white	🟢		🟢								
	Fabric - gray					🟠						
Clek - Foonf	Fabric - blue											Chlorine[5]
	Anti-rebound bar cover											Chlorine[5]
	PU foam - white					🟠						
	Warning label										🟠	Antimony[5]
Cosco - Scenera NEXT	Fabric - white										🟠	Antimony[5]
	PU foam - white	🟢		🟢	🟠							
Diono - Ranier	Fabric - gray										🟠	
	PU foam - gray		🟢									
Evenflo - Nuture	EPS foam - white										🟠	
	Fabric - pink				🟠							
Graco - Milestone	EPS foam - white										🟠	
	Fabric - black			🟢	🟠		🟠					
	PU foam - white	🟢		🟢							🟠	
	Strap cover - rubber											Antimony[5]
Graco - MyRide 65	EPS foam - white										🟠	
	Fabric - brown	🟢			🟠				🟠			
	Fabric - white	🟢		🟢	🟠				🟠			
	PU foam - white	🟢		🟢							🟠	
Joie - Stages	Fabric - black	🟢		🟢	🟠				🟠			
	PU foam - black	🟢		🟢								
Maxi-Cosi - Pria 70	Foam - blue											
	Fabric - gray	🟢										
Nuna - Pipa	EPS foam - white										🟠	
	Fabric - black			🟢	🟠		🟠					
	Fabric - gray canopy				🟠				🟠			
	Fabric - gray			🟢								
	Frame plastic - blue										🟠	
	PU foam - white			🟠 (IR)								

TABLE 8 **Results for components analyzed by GC/MS and with XRF indicators.** CONTINUED

Only chemicals detected in at least one seat in the study are included in this table. For a complete list of FR chemicals our methods were capable of detecting, see Table 5. For concentrations of quantifiable FRs, see Table 11 in the Appendix.

Seat	Component	Nonhalogen Organophosphorus					Brominated					Other[5]
		TEP[1]	TPP[1]	TBEP[1]	Cyclic Phos. Ester[2]	Unid'd P[3]	BrPS[4]	HBCD or related[4]	TBC[4]	TBB-PA[4]	Unid'd Br[3]	
Orbit Baby - G3 Toddler	Fabric - black					🟠						
	Foam - white	🟢		🟢								
	Velcro - black	🟢								🟠		
Recaro - ProRide	EPS foam - white							🟠				
	Fabric - black				🟠						🟠	
Safety 1st - Grow and Go	Fabric - black										🟠	
	Fabric - striped gray					🟠						Antimony[5]
	PU foam - gray	🟢										
	Warning label	■	■	■	■	🟠	■	■	■	■		

🟢 Identified and quantified

🟠 Identified, not quantified

■ Tested by XRF and IR only, not by GC/MS

Guide to combinations of analytical methods used:

1: Quantification by GC/MS and identification by IR

2: Identification GC/MS and/or IR

3: Elemental quantification by XRF. GC/MS was not able to identify the source of bromine or of phosphorus in some samples.

4: Identification by GC/MS 5: XRF detections of antimony above 500 ppm and chlorine

5: XRF detections of antimony above 500 ppm and chlorine between 3,500 and 10,000 ppm (the range associated with flame retardant chemicals) are noted in this column. The source of antimony and chlorine in these samples is undetermined.

CONCLUSION

IDEALLY, NO CHEMICAL FLAME RETARDANTS SHOULD BE USED IN CHILDREN'S CAR SEATS, but FRs have historically been marketed as the easiest way for manufacturers to meet the federal requirement. In general, we believe the shift from halogenated to non-halogenated FRs is a sign that manufacturers are attempting to move away from hazardous chemicals and improving control of their supply chains. Britax and Maxi-Cosi had seats this year with no detected halogens. Clek and Orbit had fabrics and foams free of bromine, although also had smaller components with bromine. We caution that some of the non-halogenated FRs show evidence of negative health effects. Designing a car seat to avoid FRs is best, but when companies do choose to add FRs, every candidate chemical should be subject to an alternatives assessment and thoroughly evaluated for exposure potential and toxicity.

Based on this year's testing, companies appear to have eliminated chlorinated organophosphate FRs such as chlorinated tris, which we found in car seats as recently as 2014. Companies have also greatly reduced contamination by heavy metals other than antimony. Companies should continue to prohibit their suppliers to use materials containing chlorinated FRs or heavy metals.

We found FRs, and especially BFRs, frequently in car seat fabrics. These appear to be understudied and should be considered as possible sources of exposure for infants and children. We detected at least three different BFRs in fabric textiles.

UPPAbaby's new infant seat, available in 2017, demonstrates that it is possible to make a car seat that meets FMVSS 302 without adding FRs. We now challenge other companies to follow suit, especially those that make low-cost seats. Car seats are required by law for children in vehicles, and an affordable seat should not come with a chemical exposure cost.

Furthermore, we urge the federal government to update FMVSS 302 to ensure that it appropriately protects children in car seats without needlessly exposing children to hazardous chemicals. Despite 44 years of this U.S. regulation, NHTSA has not provided evidence demonstrating that applying the rule to children's car seats protects children in vehicle fires. FMVSS 302 has resulted in car seat makers adding thousands of pounds of chemical flame retardants yearly to a product that infants and children are in close contact with every day.

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APPENDIX

TABLE 9 **Selected flame retardants: health and environmental information**

FR chemical	Use	Toxicity & exposure information	Environmental info	Regulatory info
Brominated polystyrene (BrPS), detected in 3 of 15 seats	Used in nylon and polyester fabric as an additive and in polystyrene as a reactive FR.[17]	Unknown. Expected to be less hazardous than non-polymeric BFRs.[17]	Likely to persist in the environment based on its halogenated structure. Low solubility in water.	
Hexabromocyclododecane (HBCD), detected in 2 of 15 seats	Common in EPS foam. Also carpet backing, computer housings, building insulation.[2]	Persistent, bioaccumulative, and toxic.18 Interfered with thyroid hormone in rats. Accumulates in fatty tissues.25 Interferes with estrogen receptors.[26]	Transported long distances through air and water. Found in wildlife and sediments in San Francisco Bay, Detroit River and Lake Erie. In Arctic air and polar bears.[27–29]	Slated for global phase-out under Stockholm Convention. Phased out of commercial use in Europe 2015.[30]
Tris(2,3-dibromopropyl) isocyanurate (TBC), detected in 3 of 15 seats	Used as an alternative to PBDEs to treat polyester textiles and many other products.	Toxic to organs in zebrafish and mice. Impairs photosynthesis and growth in algae.	Widely distributed in the environment. Has been detected in mollusks off nine coastal Chinese cities in 2009 and in all soil samples collected around Beijing in 2011.[31,32]	Listed as an IARC Group 2A carcinogen.[33]
Tetrabromobisphenol A (TBBPA), detected in 1 of 15 seats	Used as a reactive FR in printed circuit boards and an additive FR in other plastics.[8]	Binds to estrogen hormone receptors.26,34 Possible obesogen.35 Inconsistent data for human health endpoints; may bioaccumulate.[8]	Toxic to aquatic organisms.[8]	TBBPA is approved for unrestricted use in the EU, Canada and the US.[36]

TABLE 9 **Flame Retardants: Health and environmental information** CONTINUED

FR chemical	Use	Toxicity & exposure information	Environmental info	Regulatory info
Triethyl phosphate (TEP), detected in 10 of 15 seats	In the present study, very low concentration measured along with TBEP.	TEP does not pose a significant health risk for humans.37		
Triphenyl Phosphate (TPP), detected in 1 of 15 seats	Used as a flame retardant in plastic products, including car seat foams. Found in other children's products.	Not a carcinogen. May impact metabolism and contribute to obesity.23 Interferes with estrogen receptors and other sex hormones.26,38 Altered hormone levels, decreased reproductive function and developmental outcomes.39 Not highly bioaccumulative, but detection rate is high in humans due to widespread use.22,40	Highly toxic to aquatic organisms. Found in household dust,22 soil, sediment, air, and water.22	
Tris(2-butoxyethyl) phosphate (TBEP), detected in 10 of 15 seats	In addition to FR use, used in floor polishes and waxes as an antifoam agent, and as a plasticizer in plastics and rubbers.41	No studies on long-term toxicity or carcinogenicity.42 Anti-estrogenic and other hormone effects in vitro.26,38 TBEP wasin 100% of indoor dust samples from houses in North America. Found in urine43 in adults and children and in breast milk.40	World Health Organization says general health risk is low. Detected in air around the Great Lakes and in the Arctic.44,45	
Cyclic phosphonate ester, detected in 8 of 15 seats	Applied to polyester and nylon fabrics in a thermosol process.46	Not studied directly, but a representative compound for this chemical class isa possible carcinogen and may be dermally absorbed.47	Soluble in water.47	
Ammonium polyphosphate, tentatively identified in 2 of 15 seats	Used in furniture upholstery, automotive interior fabrics, draperies.47	Low toxicity to rats.6 Unlikely to be carcinogenic.47	Low to moderate toxicity to aquatic species. Low bioaccumulation potential.6 Very high persistence.8	
Antimony trioxide. (Elevated antimony was in 5 of 15 seats.)	Flame retardant synergist used in many polymers.	Does not bioaccumulate.8	Highly toxic to aquatic organisms.8	Listed as IARC possible carcinogen (by inhalation).

TABLE 10 **XRF results (parts per million) for selected elements in materials of each seat.**
The maximum concentration measured for each material type is given.

Model	Category	Sub-Category	Antimony	Bromine	Chlorine	Lead	Phosphorus
BabyTrend, Secure Snap Gear 32	Base/Frame	Handle	0	0	0	2	0
		Hard Plastic	0	17	0	1	0
		Rigid EPS Foam	0	32	378	2	0
	Harness	Clip	0	0	0	0	0
		Strap	124	186	460	0	0
	Upholstery	Fiberfill	196	11	356	1	0
		Soft Foam	0	252	0	5	6,049
		Textiles	4,867	9,127	963	6	21,374
		Velcro	0	42	387	1	0
Britax, Marathon	Base/Frame	Hard Plastic	0	1	598	6	0
		Rigid EPP Foam	0	3	360	6	0
	Harness	Clip	0	1	0	0	0
		Strap	71	0	440	7	0
	Upholstery	Fiberfill	194	1	370	3	0
		Soft Foam	0	2	396	3	0
		Textiles	235	59	728	5	0
		Velcro	0	1	324	1	0
		Warning Label	56	2	0	1	0
Chicco, KeyFit 30	Base/Frame	Handle	0	0	189	4	0
		Hard Plastic	0	0	0	0	0
		Rigid EPS Foam	0	2,182	296	5	0
	Harness	Clip	0	0	0	0	0
		Strap	110	3	0	0	0
	Upholstery	Fiberfill	187	3	493	3	0
		Soft Foam	0	2	0	1	6,091
		Textiles	116	713	478	3	9,368
		Velcro	0	2	419	2	0
		Warning Label	0	51,546	0	0	0
Clek, Foonf	Base/Frame	Anti-rebound bar	0	3	20,517	8	0
		Hard Plastic	0	0	0	8	0
		Rigid EPP Foam	237	3	435	5	0
	Harness	Clip	0	6	146	1	0
		Strap	151	175	554	0	0
	Upholstery	Soft Foam	0	3	648	2	8,882
		Textiles	201	86	4,665	6	0
		Velcro	140	3	300	1	0
		Warning Label	7,025	20,618	0	13	0
Cosco, Scenera NEXT	Base/Frame	Cup Holder	0	1	0	0	0
		Hard Plastic	0	1	0	1	0
	Harness	Strap	98	2	0	1	0
	Upholstery	Soft Foam	0	122	440	3	16,400
		Textiles	1,338	3,637	1,312	5	8,239

TABLE 10 **XRF results (parts per million) for selected elements in materials of each seat.** CONTINUED
The maximum concentration measured for each material type is given.

Model	Category	Sub-Category	Antimony	Bromine	Chlorine	Lead	Phosphorus
Diono, Rainier	Base/Frame	Cup Holder	0	0	0	1	0
		Hard Plastic	0	4	223	1	0
		Rigid EPS Foam	0	3	307	4	0
	Harness	Clip	0	0	0	0	0
		Strap	185	3	1,013	3	0
	Upholstery	Fiberfill	119	11	352	4	0
		Soft Foam	0	208	440	4	10,340
		Textiles	168	773	1,014	5	0
		Velcro	257	1,664	736	3	0
Evenflo, Nurture	Base/Frame	Hard Plastic	0	0	0	0	0
		Rigid EPS Foam	0	1,593	425	4	0
	Harness	Clip	0	0	144	0	0
		Strap	111	0	0	0	0
	Upholstery	Textiles	131	132	632	5	9,884
Graco, Milestone	Base/Frame	Cup Holder	0	0	0	0	0
		Hard Plastic	0	1	367	3	0
		Rigid EPS Foam	0	2,312	455	5	0
	Harness	Strap	143	1	0	0	0
	Upholstery	Fiberfill	249	2	467	2	0
		Soft Foam	0	6	356	4	12,319
		Textiles	7,165	6,873	2,816	10	15,010
		Velcro	0	3	408	1	0
Graco, MyRide	Base/Frame	Cup Holder	0	0	0	0	0
		Hard Plastic	0	0	0	2	0
		Rigid EPS Foam	0	1,956	323	1	0
	Harness	Clip	0	0	0	0	0
		Strap	172	1	0	0	0
	Upholstery	Fiberfill	0	3	381	2	0
		Soft Foam	0	373	384	5	20,838
		Textiles	159	14,199	636	5	5,793
Joie, Stages	Base/Frame	Hard Plastic	0	8	341	3	0
		Rigid EPS Foam	0	4	345	5	0
	Harness	Clip	0	0	0	0	0
		Strap	89	176	0	1	0
	Upholstery	Fiberfill	246	2	0	1	0
		Soft Foam	0	7	466	4	10,107
		Textiles	163	9,498	864	6	25,636
		Velcro	0	2	384	2	0

TABLE 10 **XRF results (parts per million) for selected elements in materials of each seat.** CONTINUED
The maximum concentration measured for each material type is given.

Model	Category	Sub-Category	Antimony	Bromine	Chlorine	Lead	Phosphorus
Maxi-Cosi, Pria 70	Base/Frame	Cup Holder	0	0	0	0	0
		Hard Plastic	0	1	0	1	0
	Harness	Clip	0	0	0	0	0
		Strap	167	1	0	0	0
	Upholstery	Fiberfill	173	2	0	4	0
		Soft Foam	0	4	511	5	0
		Textiles	150	153	535	4	0
Nuna, Pipa	Base/Frame	Handle	0	2	0	0	0
		Hard Plastic	0	1,033	309	6	0
		Rigid EPS Foam	0	2,030	307	0	0
	Harness	Clip	0	0	0	0	0
		Strap	63	164	330	0	0
	Upholstery	Fiberfill	177	2	329	3	0
		Soft Foam	0	1,636	366	5	11,314
		Textiles	196	8,404	513	3	30,494
		Velcro	0	46	363	3	0
Orbit Baby, G3 Toddler Convertible	Base/Frame	Hard Plastic	0	87	455	12	0
		Rigid EPP Foam	0	4	386	3	0
	Harness	Clip	0	0	0	0	0
		Strap	142	6	0	1	0
	Upholstery	Fiberfill	154	2	480	3	0
		Soft Foam	0	24	325	4	11,787
		Textiles	178	20	705	5	17,485
		Velcro	0	10,113	0	0	0
Recaro, ProRide	Base/Frame	Hard Plastic	0	0	0	1	0
		Rigid EPS Foam	0	1,092	331	5	0
	Harness	Clip	0	0	206	0	0
		Strap	159	1	0	0	0
	Upholstery	Fiberfill	117	6	402	3	0
		Soft Foam	203	19	829	6	0
		Textiles	70	724	1,320	3	27,416
Safety 1st, Grow and Go 3-in-1	Base/Frame	Cup Holder	0	0	0	0	0
		Hard Plastic	0	0	0	1	0
		Rigid EPS Foam	0	4	352	1	0
	Harness	Clip	0	0	0	0	0
		Strap	131	1	0	1	0
	Upholstery	Fiberfill	223	4	388	5	0
		Soft Foam	0	3	353	6	5,872
		Textiles	2,943	5,251	1,349	9	85,355
		Velcro	0	1	330	1	0
		Warning Label	0	4	565	2	17,151

TABLE 11 **Concentrations of FR chemicals (parts per million) that could be quantified by GC/MS.**
TBPH, TCEP, TCPP, TDCPP, TDBPP were not detected in any components. Blank means below the limit of detection.

Seat	Component	TBEP	TEP	TPP
BabyTrend - Secure Snap Gear 32	Fabric - blue canopy			
	Fabric - white			
	Fabric - black	3,200	69	
	PU foam - white	25,000		
Britax - Marathon ClickTight	Fabric - black			
	PU foam - white	14,000	110	
Chicco - KeyFit 30	EPS foam - white			
	PU foam - white	24,000	1,100	
	Fabric - gray			
Clek - Foonf	Fabric - blue			
	Anti-rebound bar cover			
	PU foam - white			
Cosco - Scenera NEXT	Fabric - white	98		
	PU foam - white	4,100	390	
Diono - Ranier	Fabric - gray			
	PU foam - gray			11,000
Evenflo - Nuture	EPS foam - white			
	Fabric - pink			
Graco - Milestone	Fabric - black	550		
	PU foam - white	19,000	1,700	
Graco - MyRide	Fabric - brown		58	
	Fabric - white	3,500	75	
	PU foam - white	23,000	580	
Joie - Stages	Fabric - black	3,800	180	
	PU foam - black	24,000	1,400	
Maxi-Cosi - Pria 70	Fabric - blue			
	Foam - grey		980	
Nuna - Pipa	EPS foam - white			
	Fabric - black	130		
	Fabric - grey canopy		88	
	Fabric - grey	2,100		
Orbit Baby - G3 Toddler	Fabric - black			
	Foam - white	24,000	1,200	
	Velcro - black		210	
Recaro - ProRide	EPS foam - white			
	Fabric - black			
Safety 1st - Grow and Go	Fabric - black			
	Fabric - striped gray			
	PU foam - gray		160	

EXHIBIT 1 **Letter**

U.S. Department of Transportation
National Highway Traffic Safety Administration

Administrator

1200 New Jersey Avenue, SE
Washington, DC 20590

July 27, 2016

The Honorable Kelly A. Ayotte
Committee on Commerce, Science, and Transportation
United States Senate
Washington, DC 20510

Dear Senator Ayotte:

Thank you for your request for information regarding the National Highway Traffic Safety Administration's (NHTSA) work on flammability standards. Below, please see answers to the questions you posed in your letter.

1. **Please describe the information or studies the Agency relied upon in creating the current flammability standard and relevant testing procedure for child car seats.**

   The Agency began pursuing a flammability standard shortly after enactment of the Safety Act in 1966 and adoption of the Agency's initial standards in 1967. In 1969, the Agency determined there was a demonstrable and urgent safety need to address flammability in the vehicle interior, as information from the National Fire Protection Association indicated there were more than 400,000 motor vehicle fires per year, and studies had shown that at least 25 percent of these fires originated in the vehicle interior. In 1971, the Agency established Federal Motor Vehicle Safety Standard (FMVSS) No. 302, "Flammability of interior materials," which generally applies to all motor vehicles with occupant compartments.

   The current FMVSS No. 302 test method has not been substantially changed from that established in 1971. Through the years, NHTSA has made minor technical changes regarding the test methodology and definitions. The test and material burn rate specified in FMVSS No. 302 was based on considerable Agency-sponsored research during the development of the standard. NHTSA's intent was to establish a reasonably low maximum burn rate for materials used in significant quantity in vehicle interiors, so as to increase the amount of time that occupants have to escape from fire.

   NHTSA extended FMVSS No. 302 to child restraints in 1981 so that all vehicle occupants are provided the protection of the standard. Flammability requirements for child restraints in the United States are the same as those in Europe and other countries. Slowing the spread of a fire is especially important when a child is restrained, since children in child restraints have to be removed from the restraint and helped out of the vehicle by another person, unlike adults who can unbuckle themselves and escape the vehicle on their own and much quicker. When the proposal to extend FMVSS No. 302 to child restraints was put forth in 1978, public comments on the issue were all supportive of child restraints meeting FMVSS No. 302.

2. **How does NHTSA assess potential chemical safety risks when evaluating the costs and benefits of a flammability standard that may necessitate use of fire retardant additives on child safety seats?**

   NHTSA's flammability standard does not necessitate the use of any particular flame retardant additive. Rather, it sets performance requirements that manufacturers must meet using any countermeasure of their choice.

   In considering potential updates to the current flammability standard, the Agency would assess the availability and cost of possible countermeasures (e.g., new types of materials, fabric barriers, and/or flame retardant chemicals) that could be used to comply with an updated standard. The Agency would only consider flame retardant chemicals that are not prohibited or restricted for use by the U.S. Environmental Protection Agency (EPA) and would take into account any established health and safety risks associated with these chemicals. Estimates of benefits of potential updates to the flammability standard would be based, to the extent feasible, on real world data of vehicle fires.

3. **Please provide a status update on the progress of the NHTSA-initiated two-year study on flammability standards, and describe the parameters of that study and outreach that will be conducted.**

   The Agency will be issuing a request for proposals in July and award a contract on its proposed research before the end of September. The two-year research program to evaluate potential improvements to FMVSS No. 302 will include evaluating different flammability test procedures and performance criteria and the burn rate of child restraints and child restraint materials with and without flame retardants. NHTSA is coordinating this research program with the EPA and the Consumer Product Safety Commission. The results of this research program will be made available to the public through publication in journals and conference proceedings and on NHTSA's website. We will look to this research to inform our next steps, which may include regulatory action.

Thank you for raising the questions in your letter. A similar response has been sent to Chairman Thune. Should you have further questions, please contact me or Alison Pascale, Director, Governmental Affairs, Policy and Strategic Planning, at 202-366-2775.

Sincerely,

Mark R. Rosekind

Mark R. Rosekind, Ph.D.

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