TOXIC BABY FURNITURE

THE LATEST CASE FOR MAKING PRODUCTS SAFE FROM THE START

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EXECUTIVE SUMMARY

Furnishings containing formaldehyde – a toxic chemical linked with allergies, asthma, and cancer – can contaminate indoor air within Maryland homes. Babies and young children are particularly vulnerable to harm.

To evaluate the potential dangers children face, Environment California Research & Policy Center purchased 21 products intended for use in a baby's nursery, hired a professional laboratory to test them and shared their results with Maryland PIRG Foundation for use in this report. Six of the products produced high levels of formaldehyde vapor. In particular, several brands of cribs and changing tables emit formaldehyde at levels linked with increased risk of developing allergies or asthma.

To protect children from formaldehyde and other chemical hazards, Maryland should adopt a new approach to chemical regulation, encouraging manufacturers to design products that are safe from the start.

Many baby nursery furnishings emit formaldehyde.

- Of the products tested, the Child Craft Oak Crib emitted the largest amount of formaldehyde. The crib includes a drawer made from composite wood, which is often manufactured using formaldehyde-based glue.
- Other products with high formaldehyde emissions included the Bridget 4-in-1 Crib by Delta, the Kayla II Changing Table by Storkcraft, the Berkley Changing Table by Jardine Enterprises, the Country Style Changing Table by South Shore Furniture, and the Rochester Cognac Crib by Storkcraft.
- The remaining 15 products tested – including the Olympia Single Crib by Jardine Enterprises; several wastebaskets, lamps, and shelves made with composite wood; and several window valances and wall hangings – emitted relatively low amounts of formaldehyde.

A baby sleeping in a nursery furnished with a high-emission crib and changing table may face an increased risk of developing allergies and/or asthma.

- A new single-family home furnished with only a Child Craft Oak Crib and a Storkcraft Kayla II Changing Table would have indoor formaldehyde levels of about 30 ppb on average throughout the whole house. A less spacious unit in a new apartment building would have indoor formaldehyde levels as high as 52 ppb. (See Table ES-1.) These estimates exclude any additional formaldehyde emissions from building materials or other pieces of furniture within the home.
- Studies have shown that chronic exposure to formaldehyde at levels greater than 16 ppb in indoor air is linked with an increased likelihood of respiratory symptoms (such as coughing) and/or allergic sensitization in children. Indoor formaldehyde levels greater than 50 ppb have been associated with an increased risk of diagnosed asthma.
- Formaldehyde appears to have a large impact on children's respiratory health. For example, in one study, 16 percent of children in homes with formaldehyde levels less than 16 ppb had diagnosed asthma,

while 44 percent had asthma in homes with indoor formaldehyde concentrations greater than 40 ppb.

- Moreover, contamination levels could be higher close to the source of emissions. For example, in a lightly ventilated nursery furnished with a Child Craft Oak Crib, formaldehyde levels could be as high as 75 ppb. Formaldehyde exposure could be even higher for an infant actually sleeping in the crib, very close to the source of emissions.

Table ES-1: Estimated Contribution of the Top Six Formaldehyde Emitters to Indoor Air Pollution Levels

Product	Manufacturer	Retailer	Estimated Contribution to Indoor Formaldehyde Levels (ppb)	
			New Single Family Home	*New Unit in Apartment Building*
Child Craft Oak Crib	Child Craft	Target	23	40
Bridget 4-in-1 Crib	Delta	Wal-Mart	11	18
Kayla II Changing Table	Storkcraft	Babies R Us	6.9	12
Berkley Changing Table	Jardine Enterprises	Babies R Us	6.2	11
Country Style Changing Table	South Shore Furniture	Target	4.2	7.2
Rochester Cognac Crib	Storkcraft	Target	3.6	6.2

How We Estimated Indoor Air Pollution Levels

Environment California Research & Policy Center hired Berkeley Analytical Associates, LLC to test the formaldehyde emissions of selected baby nursery furnishings. Laboratory staff placed each product in an environmental chamber and measured the amount of formaldehyde vapor that that was released to air. They then extrapolated the results to estimate how much each product would contribute to the formaldehyde air concentrations within a typical home. (For technical details, see the Methodology section on page 30.)

For Parents Seeking to Minimize Children's Exposure to Formaldehyde:

- Ask about the formaldehyde emissions of furniture and building products before you purchase and install them in your home.
- If such information is unavailable, avoid products with components made of raw medium density fiberboard or other types of composite wood.
- Ensure adequate ventilation within your home. Maintain moderate temperatures and humidity levels.
- Place pollution-absorbing plants – such as spider plants, Boston ferns, dwarf date palms, pot mums, or peace lilies – in your home.

Formaldehyde exposure can cause cancer in the long term.

- The International Agency for Research on Cancer and the State of California classify formaldehyde as a known human carcinogen.
- California law has determined that exposure to formaldehyde at 40 micrograms per day (equivalent to an indoor concentration of about 2 ppb) results in a 1 in 100,000 lifetime risk of cancer. Individually, the Child Craft Oak Crib, the Bridget 4-in-1 Crib, the Kayla II Changing Table, the Berkley Changing Table, the Country Style Changing Table, and the Rochester Cognac Crib each contain enough formaldehyde to contaminate an entire home with levels of formaldehyde greater than this threshold.

Formaldehyde is just one example of how the chemical regulatory system fails to protect children from health hazards.

- Inadequate resources and legal authority often prevent regulatory agencies from taking protective action – even where significant evidence of harm to public health already exists. For example, federal regulators first became aware of links between formaldehyde vapor and respiratory health problems more than 30 years ago. However, stiff resistance from the chemical industry in the early 1980s largely thwarted new rules on formaldehyde emissions. State-level action has proved to be slow as well. California declared formaldehyde to be a toxic air contaminant in 1992 – yet 16 years passed before the state successfully issued a regulation to limit emissions from composite wood. To date, Maryland has no standards to limit formaldehyde emissions from composite wood or other products.
- In addition to formaldehyde, about 1,400 chemicals on the market today have known or suspected links to cancer, birth defects, and other health problems. And tens of thousands more have not been adequately tested for health impacts.

To better protect children, Maryland should reform its system of chemical regulation. Specifically, the state should:

- At a minimum, follow California's lead and limit formaldehyde emissions from composite wood.
- Require chemical manufacturers to prove that each chemical they market is safe.
- Empower regulatory agencies to restrict or ban the manufacture and use of chemicals that pose potential dangers, erring on the side of

protecting human health and the environment.

- Ensure public access to information on chemicals and their uses through mandatory reporting requirements.

INTRODUCTION

This past year, parents got a rude awakening. Product recall after product recall made it abundantly clear that dangerous chemicals are making their way into a variety of products intended for children – and these products are finding their way onto store shelves.[1]

For example, children playing with Aqua Dots, one of Wal-Mart's best selling toys in the fall of 2007, fell seriously ill – even comatose – after swallowing the toy beads. It turned out that the beads were inadvertently coated with a chemical that turns into the "date rape" drug gamma-hydroxy butyrate after ingestion.[2] Millions of additional children were exposed to products containing dangerous levels of lead, which can interfere with normal brain development.[3]

However, countless additional products remain on store shelves, containing unregulated but hazardous chemicals. Many of these chemicals can cause long-term health problems such as asthma or cancer. Parents can unknowingly bring these chemicals into their homes, where they can adversely affect the health of their families.

In this report, we tell the story of formaldehyde. Despite indications that indoor air contaminated with formaldehyde posed a threat to respiratory health as early as 1976, common consumer products – such as the baby nursery furnishings we identify in the pages that follow – can still emit formaldehyde.

Maryland currently has no regulations to limit the amount of formaldehyde emissions from products of any kind. However, other states are taking action to limit exposure to this chemical. In April 2008, the California Air Resources Board finalized a new rule to limit the amount of formaldehyde emissions from products made of composite wood that are manufactured, sold or used in California.[4] With vigorous enforcement, this regulation will reduce public exposure to formaldehyde in California, and may help set a precedent for other states – including Maryland.

However, formaldehyde – and the toxic substances involved in previous recalls – represent just the tip of the iceberg when it comes to chemical hazards in consumer products.

There are more than 75,000 industrial chemicals on the market in the United States.[5] The health effects of almost half of the major industrial chemicals have not been studied at all.[6] Of those that have been studied, approximately 1,400 chemicals with known or probable links to cancer, birth defects, reproductive impacts, and other health problems are still in use today.[7] Many of these chemicals end up in products that we buy and take into our homes, unbeknownst to consumers.

When the federal government created the Toxic Substances Control Act in response to the PCB crisis 30 years ago, the chemical industry succeeded in making sure there were no new testing requirements placed on the tens of thousands of chemicals already in use. For new chemicals, the law required only a rapid pre-market screening based on existing information, and did not require toxicity testing for health effects.

In other words, regulatory agencies can only act after a product has proven to be unsafe. This approach is far less stringent than the process for approving drugs, where the U.S. Food and Drug Administration requires thorough pre-market testing and ongoing evaluation of drug effectiveness and safety.

As a result, U.S. chemical regulation stumbles blindly, using an "innocent until proven guilty" model, allowing widespread exposure to toxic chemicals before they have been tested for safety. Moreover, where significant evidence of harm to public health already exists, inadequate resources and legal authority often prevent regulatory agencies from taking protective action.

In the absence of strong federal action, states are moving forward with regulatory reform on their own. California, Maine, and Washington have all taken strong steps in the past two years to phase out the use of specific classes of chemicals linked to developmental disorders, cancer and other health problems. However, more comprehensive actions are needed to protect our children from unnecessary exposure to toxic chemicals. An innovative approach called the Green Chemistry Initiative was launched by California Governor Schwarzenegger and Secretary for Environmental Protection Linda Adams in April 2007, called the Green Chemistry Initiative.[8] Green Chemistry "is a preemptive strategy to stop toxic substances before they contaminate the environment and our bodies."[9] Green Chemistry seeks to reduce and eliminate hazardous substances in products by design, minimizing public health and environmental impacts from the start.

The time has come for the state of Maryland to take action and to offer parents new assurance that everyday consumer products are safe to bring home from the store and to use in caring for their families.

THE HEALTH RISKS OF FORMALDEHYDE EXPOSURE

Formaldehyde is a toxic chemical widely used in building materials and a variety of household products. For example, manufacturers use formaldehyde as a component in glues and adhesives, as a preservative in paints and related products, and as a means to give fabrics a permanent-press quality.

When used in the home, formaldehyde-containing products can release the chemical into indoor air. In particular, products made from composite wood containing urea-formaldehyde glue tend to create indoor air pollution.[10]

Children chronically exposed to elevated levels of airborne formaldehyde face an increased risk of developing allergic sensitivities and/or asthma. Moreover, the International Agency for Research on Cancer and the State of California classify formaldehyde as a known human carcinogen.

FORMALDEHYDE IS AN INDOOR AIR POLLUTANT

The air within just about every indoor space in Maryland likely contains measurable levels of formaldehyde.

Although there is no readily available data on average formaldehyde concentrations in Maryland homes, it is likely that formaldehyde concentrations in Maryland homes are similar to those in California, since the states have comparable building standards.[11]

According to the California Air Resources Board, the average California home contains formaldehyde at more than 10 parts per billion (ppb).[12] In the most contaminated homes, formaldehyde levels exceed 200 ppb.[13] In one study published in 2000, findings showed that new homes – even before the addition of furnishings – had formaldehyde levels averaging 40 ppb.[14]

Similar levels of contamination can be found in school classrooms in California, and levels in manufactured homes can be more than twice as high.[15] Marylanders likely experience similar levels of exposure to formaldehyde.

WHERE DOES FORMALDEHYDE CONTAMINATION COME FROM?

Consumer products and building materials manufactured using formaldehyde as an ingredient are a main source of indoor air pollution. Potential formaldehyde emission sources within a home include:[16]

- Furniture and building materials made from composite wood;
- Some types of fiberglass insulation;
- Permanent press textiles;
- Cosmetics (especially liquid fingernail products); and
- Combustion sources, including cigarettes.

In homes, composite wood products made with urea-formaldehyde resin are likely to be among the most significant sources of airborne formaldehyde. Manufacturers use urea-formaldehyde because it is cheap and transparent. However, products made with this adhesive tend to have very high formaldehyde emissions, which continue for several years after manufacture.[17] Heat and humidity tend to accelerate formaldehyde emissions, especially when a product is new.[18]

In particular, Medium Density Fiberboard (MDF), a type of composite wood widely used in building materials and furniture, is a notorious source of formaldehyde vapor in the home.[19] Particle board and hardwood plywood are two additional types of compressed wood made with formaldehyde-based glue.

Outdoor air also contains significant levels of formaldehyde as a byproduct of fuel combustion in cars and trucks. However, indoor sources of formaldehyde account for nearly 80 percent of a typical person's daily exposure.[20]

The Home as a Toxic Environment

Not all toxic chemicals enter the environment dripping from a factory waste pipe, leaking from a hazardous waste dump at the edge of town, or billowing into the air from an incinerator smokestack. Products made in factories and shipped to homes and offices around the state also contain hazardous materials, where they become an intimate part of the life of every Maryland resident.

Substantially more chemicals are shipped from factories to homes, contained within consumer products, than are spilled or dumped into the environment. Massachusetts, one of the few states where companies are required to report the amounts of chemicals they use and ship in products, provides a good illustration. In Massachusetts in 2001, for every one pound of chemicals released or disposed of, eight pounds were distributed in manufactured products.[21] Companies shipped thousands of times more of certain toxic chemicals – especially ingredients in plastics and personal care products – than they released into the environment.[22]

As a result, children today grow up surrounded by many chemicals that did not exist a hundred years ago. Their food containers are made with plastic containing potentially harmful chemicals. Their homes and yards are treated with pesticides. Their families use cosmetics and personal-care products that contain hundreds of synthetic chemicals. Many of these chemicals escape from products and end up in household dust and in household air.[23] The chemicals have become such a close part of our lives that now they can be found in the blood and bodies of every mother and child.[24]

Formaldehyde Exposure Is Associated with Allergies, Asthma, and Cancer

Acute exposure to elevated levels of formaldehyde can irritate skin and respiratory tissue, leading to inflammation and triggering asthma attacks. When formaldehyde is present in the air at levels exceeding 100 parts per billion (ppb), some individuals may suffer from watery eyes; burning sensations of the eyes, nose, and throat; coughing; wheezing; nausea; and skin irritation. People repeatedly exposed to formaldehyde may develop a sensitivity to this chemical, increasing the severity of effects over time.[25]

However, lower levels of formaldehyde also pose significant hazards, especially over longer periods of time. Scientific studies have linked long-term exposure to formaldehyde with increased odds of developing health problems ranging from asthma to cancer. Babies and young children are particularly vulnerable to harm since they are growing rapidly, with immature and vulnerable respiratory and other organ systems.

CHILDREN CHRONICALLY EXPOSED TO FORMALDEHYDE ARE MORE LIKELY TO DEVELOP ASTHMA OR ALLERGIES

In August 2007, Dr. Mark Mendell at the Lawrence Berkeley National Laboratory in Berkeley published a review of peer-reviewed scientific studies examining the health risks of exposure to indoor air pollutants, including formaldehyde.[26] He identified 21 relevant studies, many of which linked formaldehyde exposure at levels that are likely to be found in Maryland homes to increased risk of respiratory symptoms, allergic sensitization, and doctor-diagnosed asthma. For example:

- Dr. Martin Hooper at Monash University in Victoria, Australia, and his colleagues found that children exposed to formaldehyde at levels as low as 16 ppb in indoor air were more likely to show allergic sensitization and respiratory symptoms such as coughing.[27] Moreover, 16 percent of children in homes with formaldehyde levels less than 16 ppb had diagnosed asthma, while 44 percent had asthma in homes with indoor formaldehyde concentrations greater than 40 ppb.
- Dr. Krassi Rumchev at the Curtin University of Technology in Perth, Australia, and his colleagues found that children between 6 months and 3 years of age chronically exposed to formaldehyde at levels higher than 50 ppb showed an increased prevalence of asthma.[28] The scientists studied a group of children with doctor-diagnosed asthma, and a group of children of similar age without asthma. They then tested the children's bedrooms and living rooms for formaldehyde contamination, controlling for temperature and humidity. The risk of a child needing treatment for asthma increased by 39 percent with residential formaldehyde concentrations greater than 50 ppb – and the risk increased as formaldehyde levels increased.
- Dr. Michal Krzyzanowski and his colleagues at the University of Arizona Health Sciences Center in Tucson found that children exposed to formaldehyde levels greater than 60 ppb were significantly more likely to have asthma or chronic bronchitis, especially in homes with elevated levels of second-hand tobacco smoke.[29] Children exposed to greater amounts of formaldehyde also showed significantly decreased measures of lung function – a child exposed to 60 ppb formaldehyde lost about 20 percent of exhalation force compared to an unexposed child. Asthmatic children were particularly sensitive to this effect, while adults were less sensitive.
- Dr. Peter Franklin and his colleagues at Princess Margaret Hospital for Children in Perth, Australia, found that children living in homes with formaldehyde levels greater than 50 ppb showed elevated levels of nitric oxide in their breath, an indicator of swelling deep within the lungs and development of asthma.[30]
- Dr. Jouni Jaakkola at the University of Helsinki in Finland and his colleagues found that 8 – 12 year old schoolchildren were more likely to suffer from asthma, wheezing, or allergies when exposed to new linoleum flooring, synthetic carpeting, particleboard, wall coverings, furniture, or new paint.[31] New particleboard and furniture – both likely sources of formaldehyde

emissions – were significantly associated with allergies, and showed an association, albeit not statistically significant, with wheezing and asthma.

The scientific literature to date shows associations between formaldehyde exposure and inflammation of lung tissues, sensitization to allergens, and potentially altered immune system development in children, all of which are involved in the development and progression of asthma.[32]

Chronic Exposure to Formaldehyde Can Cause Cancer

Formaldehyde exposure can also cause cancer in both humans and animals. The International Agency for Research on Cancer (IARC) and the State of California both classify formaldehyde as a known human carcinogen.[33]

In one of the many studies evaluated by IARC, workers with a greater exposure to formaldehyde showed a higher risk of developing cancer.[34] Industrial workers exposed to formaldehyde were more likely to die from cancer in the back of the throat (or nasopharyngeal cancer) when compared to typical American citizens.[35] The study also showed a link, albeit weaker, between formaldehyde exposure and leukemia.[36] The link is supported by experiments within the laboratory, which show that formaldehyde causes damage to DNA in the upper respiratory tissues of both humans and rodents after inhalation.[37]

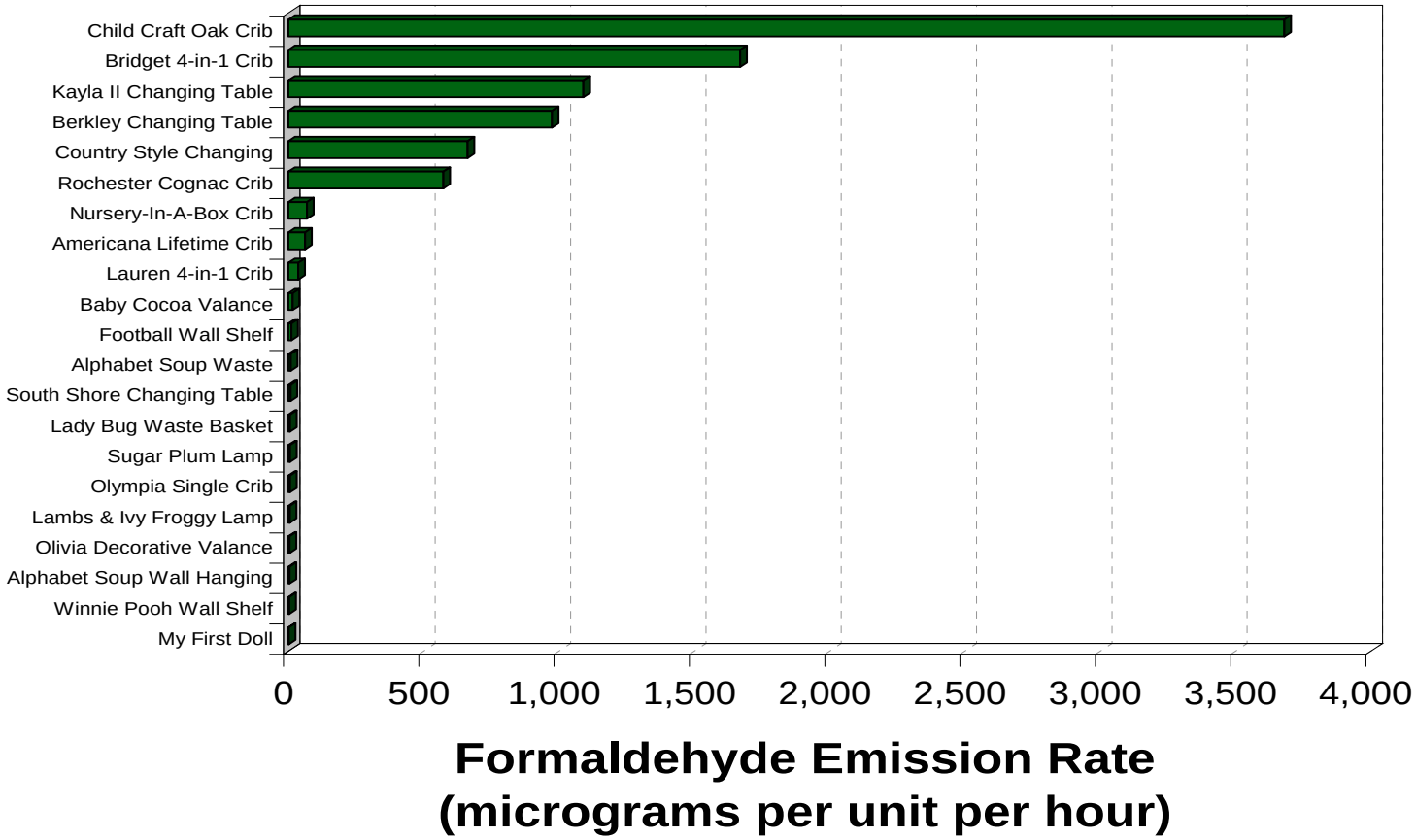
Testing Results: Many Baby Nursery Furnishings Emit Formaldehyde

To evaluate the potential dangers children face from exposure to chemicals, Environment California Research & Policy Center purchased 21 consumer products and tested their formaldehyde emissions. The organization's staff assumed the role of prospective parent and looked for cribs, changing tables, window dressings, shelves, and related items found in a typical baby nursery. They shopped at Babies "R" Us, Wal-Mart, and Target; both on-line and in-store. Staff looked particularly for items containing composite wood or permanent press fabrics, which they believed could be potential sources of formaldehyde.

Environment California Research & Policy Center then hired a professional laboratory, Berkeley Analytical Associates, LLC, to test the products. Laboratory staff placed each product in a continuously ventilated environmental chamber for 24 hours and measured the amount of formaldehyde vapor that that was released each hour. They then extrapolated the results to estimate the contribution of each product to the formaldehyde concentrations in the air within a typical home. (For technical details, see the Methodology section on page 30.) Finally, Environment California staff shared their work with Maryland PIRG Foundation to form the basis of this report.

The findings reveal that six of the products emitted formaldehyde vapor at high rates. (See Figure 1.) In particular, several brands of cribs and changing tables emit formaldehyde at levels that increase the risk of children developing allergies or asthma.

Figure 1: Formaldehyde Emissions of Selected Baby Nursery Furnishings



FURNITURE CONTAINING COMPOSITE WOOD SHOWED THE HIGHEST EMISSIONS

Products with components made from composite wood showed the highest level of formaldehyde emissions.

Of the products tested, the Child Craft Oak Crib showed the highest rate of formaldehyde emission. The crib includes a drawer made from composite wood.

Other products with high formaldehyde emissions included:

- Bridget 4-in-1 Crib by Delta,
- Kayla II Changing Table by Storkcraft,
- Berkley Changing Table by Jardine Enterprises,
- Country Style Changing Table by South Shore Furniture, and
- Rochester Cognac Crib by Storkcraft.

Table 1 summarizes the test results for the highest emitting products, along with the product manufacturers and the retail outlets where they were purchased.

Table 1: Products with High Formaldehyde Emissions

Product	***Manufacturer***	***Retailer***	***Formaldehyde Emissions (micrograms per unit per hour)***
Child Craft Oak Crib	Child Craft	Target	3,680
Bridget 4-in-1 Crib	Delta	Wal-Mart	1,670
Kayla II Changing Table	Storkcraft	Babies R Us	1,090
Berkley Changing Table	Jardine Enterprises	Babies R Us	974
Country Style Changing Table	South Shore Furniture	Target	662
Rochester Cognac Crib	Storkcraft	Target	573

A Home Furnished with High-Emitting Products Likely Increases a Child's Risk of Developing Allergies or Asthma

Placing just one or two of the products identified in this report as high-emitting sources into a home would result in significantly elevated indoor formaldehyde levels. For example, the formaldehyde concentration in the air of a new single-family home furnished with only a Child-Craft Oak Crib would be greater than 20 ppb. Children chronically exposed to formaldehyde at this level in one study were more likely to show respiratory symptoms such as coughing.

However, the typical home likely contains more than one source of formaldehyde emissions. Homes also can have poor ventilation, or small indoor volume. In these cases, formaldehyde levels could easily exceed 50 ppb, entering the range where scientists have observed increased risk of asthma and allergy development in children.

Indoor Formaldehyde Levels

Formaldehyde concentrations within a home are dependent on three factors:

1) The volume of the home;
2) Its ventilation rate; and
3) The formaldehyde emissions of each product within the home.

Homes with low volume, poor ventilation, and a large number of formaldehyde-emitting products will tend to have high levels of indoor air pollution. Conversely, large homes with high ventilation and few products emitting formaldehyde will have indoor formaldehyde levels closer to those in outdoor air.

It is likely that Maryland homes are poorly ventilated. The building codes for Maryland homes are similar to those in California.[38] And according to a June 2007 survey conducted by the California Air Resources Board, only 10 percent of California homes have adequate ventilation.[39] Increased focus on security, and especially energy conservation, limits ventilation rates. In other words, the typical Maryland home is likely susceptible to high indoor air pollution levels.

All other factors being equal, new homes will tend to have higher levels of indoor air pollution. Over time, home construction and home energy efficiency have improved, and new homes are increasingly better sealed against the outdoors.[40]

However, new homes also are more likely to be larger than older homes, partially offsetting this effect. Looking at median estimates for single-family home size, for example, Berkeley Analytical Associates concludes that a typical new single-family home encloses about 60 percent more air volume than an existing home.[41]

Evaluating the Health Risks Posed by Individual Products

To evaluate the health risks posed by each of the products tested in this report, we estimated how each product would impact indoor air quality in a typical home.

The formaldehyde emission rate of each product was determined by Berkeley Analytical Associates through closed chamber testing. We then used assumptions about the size and ventilation rates of typical Maryland homes to estimate each product's contribution to indoor formaldehyde levels. The assumptions, developed by the

laboratory, describe typical air volumes and ventilation rates of single-family homes and units in apartment buildings, covering both existing and new buildings.[42] (For full details, see the Methodology section on page 30.)

Under these assumptions, smaller homes with low ventilation rates, typical of new units in apartment buildings, would be most likely to have high formaldehyde concentration levels with a given set of furniture. Correspondingly, existing single-family homes, with higher ventilation rates and the same furniture, would most likely have lower formaldehyde levels.

Table 2 shows the estimated contribution of each of the six products identified as having high formaldehyde emissions to whole-house formaldehyde concentrations in various types of residences.

Table 2: Estimated Contribution of High-Emitting Products to Whole-House Formaldehyde Levels

	Total House Concentration (ppb)			
Product Name	***Existing Single Family***	***New Single Family***	***Existing Apartment***	***New Apartment***
Child Craft Oak Crib	17.6	23.3	29.4	39.8
Bridget 4-in-1 Crib	8.0	10.6	13.3	18.1
Kayla II Changing Table	5.2	6.9	8.7	11.8
Berkley Changing Table	4.7	6.2	7.8	10.5
Country Style Changing Table	3.2	4.2	5.3	7.2
Rochester Cognac Crib	2.7	3.6	4.6	6.2

Respiratory Risks

To put the information in table 2 into context, scientists have observed that children exposed to indoor formaldehyde levels greater than 16 ppb show increased risk of allergic sensitization and respiratory symptoms, and increased likelihood of having asthma at formaldehyde levels above 50 ppb.[43]

A typical single-family home – new or existing – furnished with only a Child Craft Oak Crib would have indoor formaldehyde levels above 16 ppb. If the crib were placed in a new apartment unit, indoor formaldehyde levels could approach 40 ppb.

Add in a Storkcraft Kayla II Changing Table along with the Child Craft Oak Crib, and indoor formaldehyde levels would exceed 50 ppb in a new apartment.

These estimates are for typical homes. In homes with worst-case conditions – small indoor space and very poor ventilation – indoor air pollution levels could be considerably higher.

Also, most homes contain additional furnishings and building materials that contain formaldehyde. Formaldehyde emissions from cribs and changing tables in a home will add to pollution from these other materials, increasing the odds that a high-emission product could expose a child to an increased risk of allergies or respiratory disease.

Contamination Levels Could Be Higher within a Baby's Nursery

A baby nursery containing formaldehyde-emitting products will likely have higher concentrations of formaldehyde than the average levels throughout the home.

Consider a hypothetical situation: a parent furnishes a 150 square foot baby nursery with a Child Craft Oak Crib. Assume that this room is ventilated such that the air volume fully recycles once every hour. This nursery could have a formaldehyde concentration as high as 75 ppb.[44] If the nursery had poor ventilation, with one air change every two hours, formaldehyde concentrations could potentially reach 150 ppb or more.

Moreover, formaldehyde exposure will likely be even higher the closer one gets to the source of the emissions. For example, the Child Craft Oak Crib includes a composite wood drawer beneath the mattress platform, likely delivering elevated amounts of formaldehyde to a sleeping infant.

In the scientific studies on childhood respiratory health discussed earlier, however, estimates of children's exposure were made by measuring formaldehyde concentrations in various rooms within a home. The health consequences of periodic exposure to elevated levels of formaldehyde, similar to what would be experienced by an infant periodically sleeping in a high-emission crib, have not been specifically studied.

Cancer Risks

California's Office of Environmental Health Hazard Assessment considers formaldehyde exposure at any level to pose a health risk, with no lower threshold with zero risk.[45]

However, for regulatory purposes, California has set a long-term "no significant risk level" for cancer from formaldehyde exposure at 40 micrograms per day.[46] Exposure at this level over a 70-year lifetime would produce one excess case of cancer in 100,000 people.[47] Under California law, exposure to formaldehyde above this level would require a posted warning for consumers.[48] A 40 microgram

per day dose is roughly equivalent to an indoor formaldehyde concentration of 2 ppb.

Individually, the Child Craft Oak Crib, Bridget 4-in-1 Crib, Kayla II Changing Table, Berkley Changing Table, Country Style Changing Table, and Rochester Cognac Crib each emit formaldehyde at sufficiently high rates to contaminate an entire home with levels of formaldehyde greater than this threshold.

Other Products Emitted Smaller Amounts of Formaldehyde

In addition to the six cribs and changing tables identified as high-emitting products, Environment California Research & Policy Center tested 15 other products with potential to emit formaldehyde. Researchers examined several additional cribs and changing tables, plus lamps, shelves, and wastebaskets potentially made with composite wood parts. They also tested a few window valances, wall hangings, and a doll made with permanent-press fabric potentially treated with formaldehyde-containing chemicals during manufacturing.

Almost all of these items emitted measurable amounts of formaldehyde, but at rates several orders of magnitude lower than the high-emitting cribs and changing tables identified earlier in the report. (See Table 3.)

Researchers also estimated the contribution that each of these products would make to overall formaldehyde concentrations within typical homes. (See Table 4.) Individually, none of these products would add more than 0.74 ppb formaldehyde to the indoor air of a home. In comparison, the average level of formaldehyde in outdoor areas of California is 3 ppb, exceeding 10 ppb in areas with high vehicle traffic.[49] Outdoor formaldehyde levels in Maryland are similar.[50] We conclude that these products individually pose a relatively small additional health risk.

However, these products may cumulatively contribute to measurable formaldehyde air contamination within a home. For example, if a family furnished a new home with a Nursery-In-A-Box Crib and two additional items with equivalent emissions, indoor formaldehyde levels would just exceed the "no significant risk level" for cancer of 40 micrograms per day (equivalent to an indoor concentration of about 2 ppb) used in California regulations.[51]

Table 3: Products with Relatively Low Formaldehyde Emissions

Product	Manufacturer	Retailer	Formaldehyde Emissions (micrograms per unit per hour)
Nursery-In-A-Box Crib	Simplicity for Children	Wal-Mart	69
Americana Lifetime Crib	Jardine Enterprises	Babies R Us	62
Lauren 4-in-1 Crib	Graco	Target	36
Baby Cocoa Valance	Lambs & Ivy	Babies R Us	16
Football Wall Shelf	Trend Lad	Target	11
Alphabet Soup Waste Basket	Cocalo	Babies R Us	9
South Shore Changing Table	South Shore Furniture	Babies R Us	8
Ladybug Wastebasket	Kids Line	Babies R Us	6
Sugar Plum Lamp	Cocalo	Babies R Us	6
Olympia Single Crib	Jardine Enterprises	Babies R Us	<6
Lambs & Ivy Froggy Lamp	Lambs & Ivy	Babies R Us	5
Alphabet Soup Wall Hanging	Cocalo	Babies R Us	4
Olivia Decorative Valance	Kids Line	Babies R Us	4
Winnie Pooh Wall Shelf	Crown Crafts Infant Products, Inc.	Babies R Us	3
My First Doll	Koala Baby	Babies R Us	1

Table 4: Estimated Contribution of Low-Emitting Products to Whole-House Formaldehyde Levels

	Total House Concentration (ppb)			
Product Name	*Existing Single Family*	*New Single Family*	*Existing Apartment*	*New Apartment*
Nursery-In-A-Box Crib	0.33	0.44	0.55	0.74
Americana Lifetime Crib	0.30	0.39	0.50	0.67
Lauren 4-in-1 Crib	0.17	0.23	0.29	0.39
Baby Cocoa Valance	0.07	0.10	0.12	0.17
Football Wall Shelf	0.05	0.07	0.09	0.12
Alphabet Soup Waste Basket	0.04	0.06	0.07	0.10
South Shore Changing Table	0.04	0.05	0.07	0.09
Lady Bug Waste Basket	0.03	0.04	0.05	0.07
Sugar Plum Lamp	0.03	0.04	0.05	0.07
Olympia Single Crib	<0.03	<0.04	<0.05	<0.06
Lambs & Ivy Froggy Lamp	0.02	0.03	0.04	0.05
Alphabet Soup Wall Hanging	0.02	0.03	0.03	0.05
Olivia Decorative				

How the Current Chemical Regulatory System Fails Children

The story of formaldehyde encapsulates what is wrong with federal and state approaches to chemical regulation.

First, inadequate resources and legal authority often prevent regulatory agencies from taking protective action – even where significant evidence of harm to public health already exists. In the case of formaldehyde, regulators first became aware of links between emissions in homes and respiratory damage and cancer in the 1970s. However, stiff resistance from the chemical industry has largely thwarted new federal rules addressing formaldehyde exposure. Maryland regulators have taken no action to limit indoor exposure to formaldehyde. And in California, arguably the state pursuing solutions to the problem of indoor formaldehyde exposure most vigorously, 16 years elapsed between official declaration of formaldehyde as a toxic air contaminant and rules limiting formaldehyde emissions from composite wood. Meanwhile, the number of children with asthma is rising. Childhood asthma doubled in prevalence between 1980 and 1995, reaching 7.5 percent of all children.[52]

Second, formaldehyde is just one of more than a thousand chemicals on the market that have documented links to disease.[53] And tens of thousands of additional chemicals on the market have not been adequately tested for health impacts.[54] Under Maryland's current approach to chemical regulation, these potential hazards will be addressed on a piecemeal, chemical-by-chemical basis – if at all. Moreover, by the time regulators are able to draft and issue effective rules, harm to public health will have already happened – and in many cases will have been ongoing for decades.

Inadequate Resources and Legal Authority Often Prevent Regulatory Action

At the federal level, the primary law governing industrial chemicals – the Toxic Substances Control Act (TSCA) – has failed to live up to its purpose of protecting the public from toxic exposures. Even with strong evidence that chemicals pose health hazards, regulators often lack either the legal authority or the political will to take protective action. Action must overcome resistance from consumer product manufacturers accustomed to using a particular chemical, and from a chemical industry reliant on the profits from its sale.

The history of regulatory action on formaldehyde provides a good example.

Federal Action on Formaldehyde

In the 1970s, many builders used urea-formaldehyde foam insulation (UFFI) to improve home energy efficiency. After installation of the material, homes showed elevated levels of formaldehyde vapor.[55]

As early as 1976, the federal Consumer Product Safety Commission (CPSC) began to hear complaints of respiratory irritation from residents living in homes insulated with UFFI.[56] The CPSC began to investigate what might be causing the irritation, and whether a new regulation was necessary.

In 1979, researchers experimenting with rats discovered that formaldehyde can cause cancer.[57] The CPSC, along with the U.S. Environmental Protection Agency (U.S. EPA), the Occupational Safety and Health Administration (OSHA), and other regulatory agencies evaluated the findings. They concluded that "the concentrations of formaldehyde in inhaled air that caused nasal cancer in … rats are within the same order of magnitude as those to which humans may be exposed."[58]

However, attempts to draft new regulations met with stiff resistance from the Formaldehyde Institute, a coalition of industries dependent on the chemical. As the Reagan Administration came into office in 1981, the Formaldehyde Institute held a series of meetings with agency leaders. Actions to regulate formaldehyde at U.S. EPA and OSHA were curtailed shortly thereafter.[59] Public interest organizations and several members of Congress pointed to undue influence from industry in the decision not to act.[60]

The CPSC established new regulations on UFFI, and ultimately voted to ban the product in February 1982. However, this action too was voided, after the Fifth Circuit Court of Appeals upheld a lawsuit by the Formaldehyde Institute claiming that the CPSC used a flawed decision-making process.[61]

In 1985, the U.S. Department of Housing and Urban Development (HUD) issued a limited regulation aimed at keeping formaldehyde levels in manufactured homes below 400 ppb.[62] This limited rule (which applies to hardwood plywood and particleboard used as building materials in manufactured homes, but not medium-density fiberboard) is currently the only federal limit on formaldehyde in consumer products sold in the United States.[63] In comparison, Japan's standards allow only one-tenth as much formaldehyde emissions.[64] The European Union also has stronger limits.[65] Even China has stringent limits on the formaldehyde content of building materials – although they do not apply to products exported to the United States.[66]

California regulators estimate that the HUD standard still allows 23 to 63 excess cancer cases per million children exposed for nine years, and 86 to 231 excess cancer cases per million adults exposed over a 70-year lifetime.[67] Respiratory and allergic health impacts would affect many more children, if exposed to formaldehyde at this level. Moreover, the HUD standard only applies to wood used in manufactured homes, and not other types of products.

In place of official regulation, the composite wood industry adopted voluntary standards for formaldehyde emissions, which have kept the emissions from the average composite wood product at about 40 percent below the HUD standard.[68] However, these voluntary limits have not gone far enough to reduce indoor formaldehyde contamination to safe levels.

Formaldehyde Regulation in The States

State regulatory actions have proven to be equally slow.

Maryland has no independent regulations to limit formaldehyde exposure from products. However, California formally declared formaldehyde to be a toxic air contaminant in 1992.[69] The Office of Environmental Health Hazard Assessment recommended that "formaldehyde be treated as having no threshold exposure level below which no significant adverse health impacts are anticipated."[70]

State law requires the California Air Resources Board (CARB) to take action to reduce public exposure to toxic air contaminants, requiring the use of best available control technology that is technically available and economically feasible.

However, ARB took little official action on formaldehyde until 2001, when it proposed a ban on all composite wood products made with urea-formaldehyde resin.[71] The composite wood industry argued against the measure, and in 2003, ARB ultimately decided to hold off on a ban.

California's 2008 Formaldehyde Regulation

While there are no proposed regulation actions for formaldehyde in Maryland at this time, California is leading the way. In 2006, CARB proposed a new regulation limiting the emissions of formaldehyde from composite wood boards. The regulation applies at the level of board manufacturing, reducing allowable emissions from the raw materials later used in furniture and buildings.

For particleboard and hardwood-plywood, the regulation limits allowable formaldehyde emissions to 259 micrograms per square meter of board surface per hour beginning January 2009, and to 129 by 2011-2012. Regulators set formaldehyde emission limits for medium density fiberboard at roughly double these amounts.[72]

The new regulation officially became California law on April 18, 2008.[73]

CARB estimates that the regulation will reduce formaldehyde emissions from composite wood products by 180 tons per year in the first phase, reducing individual exposures by 15 percent. In the second phase, CARB expects to reduce emissions by 500 tons per year, and individual exposures by 40 percent.[74]

This new rule will help to reduce indoor exposure to formaldehyde. However, it comes more than 30 years after federal regulators identified formaldehyde as a potential respiratory hazard, and 16 years after California officially determined that formaldehyde was a toxic air contaminant.

California's New Formaldehyde Emission Rules and the Products Tested in this Report

The Child Craft Oak Crib is made with composite wood that very likely will not meet the upcoming CARB formaldehyde emission standards. The Bridget 4-in-1 Crib, the Kayla II Changing Table, and the Berkley Changing Table include composite wood parts that likely exceed the CARB standard. And the Country Style Changing Table and the Rochester Cognac Crib include parts that may exceed the standard.

If the construction of these products is changed to use boards that will comply with the CARB regulation, they likely will emit much less formaldehyde. However, the new CARB regulation is limited in several ways:

- The regulation will not apply to products intended for sale outside of California.
- The regulation will not eliminate formaldehyde emissions from consumer products. For example, even under CARB's most stringent limit for formaldehyde emissions from medium density fiberboard, a home containing 20 square meters of the product would still contain 25 to 55 ppb formaldehyde, depending on home size and ventilation rate. To

put that in perspective, seven bookcases with dimensions of 13" x 31" x 70" and with no lamination on the undersides of shelves and the rear of the unit, would have 20 square meters of exposed composite wood surface.

- The rule also applies only to composite wood. Products that use other types of formaldehyde-emitting materials will not be affected.

Formaldehyde Is Just One of Thousands of Hazardous Chemicals on the Market

Formaldehyde is one of a vast expanse of chemical hazards facing children that grow up in today's world. Most of these threats have yet to be effectively addressed by either the federal or the state of Maryland's chemical regulatory systems.

Chemical manufacturers produce and market more than 75,000 different chemicals for use across the U.S. economy.[75] 1,400 of these chemicals have known or probable links to cancer, birth defects, reproductive impacts, and other health problems that plague our society.[76] And the health effects of almost half of the major industrial chemicals – roughly 1,500 compounds – have not been studied at all.[77]

Many of these chemicals are becoming part of our very bodies in complex mixtures that have never been evaluated to determine their impact on human health.

For example, the Environmental Working Group recently found 287 different chemicals in the umbilical cord blood of 10 randomly selected infants born in the United States.[78] These chemicals included "pesticides, consumer product ingredients, and wastes from burning coal, gasoline and garbage."[79] Of the chemicals detected, 180 are known to cause cancer in humans or animals; 217 have toxic effects on the brain and nervous system; and 208 cause birth defects or developmental problems in experiments with animals.[80] No study has ever evaluated the impact of this complex mixture of pollutants on fetal or infant health.

Under the current regulatory framework, the burden of proving harm falls upon those exposed to chemical hazards. Regulators are faced with the task of assessing risks faced by the public, one chemical at a time. They must document public exposure, uncovering where the chemical is produced, used, discharged, and disposed of. Then regulators must evaluate associations between exposure and diseases. Finally, regulators must go through the arduous process of crafting and issuing new rules – a process that can take decades between hazard identification and action to reduce public exposure, if it does not fail outright.

The result is that children continue to be exposed to hazardous chemicals – such as formaldehyde – every day.

A New Approach: Green Chemistry

Reforming and empowering Maryland's chemical regulatory system to require manufacturers to consider potential impacts on public health and the environment up-front, during product design, could provide a much more effective means to reduce our exposure to dangerous chemicals in consumer products.

Several states outside Maryland, including California, are beginning to recognize this possibility. California Governor Schwarzenegger and Secretary for Environmental Protection Linda Adams launched the California Green Chemistry Initiative in April 2007.[81] Green chemistry "is a preemptive strategy to stop toxic substances before they contaminate the environment and our bodies."[82] Green chemistry seeks to reduce and eliminate hazardous substances in products by design, minimizing public health and environmental impacts. Maryland leaders should consider a similar approach to protect public health in our state.

In order to be meaningful, the chemical regulatory reform should be more than a voluntary, incentive-based program. The state needs to create the regulatory infrastructure to assess chemical safety and restrict or phase out the use of the most dangerous substances.

For example, if an effective green chemistry approach had been in place in 1992 when California classified formaldehyde as a toxic air contaminant, children's exposure to formaldehyde would look very different today. Instead of spending several decades studying exposure and characterizing shades of risk, regulators could have judged that formaldehyde, as an intrinsically hazardous chemical, should not be used in applications that lead to human exposure, especially where safer alternatives are available. Guided by this judgment, composite wood, building material, and furniture manufacturers could have deployed alternative adhesives or materials free from formaldehyde emissions. The same process would have guided manufacturer decisions about other dangerous chemicals that still await meaningful regulatory action. The result would have been healthier indoor air for children to breathe and reduced exposure to a range of health-threatening substances.

Now, we have an opportunity to make this vision a reality. By undertaking comprehensive reform of chemical regulation and embracing green chemistry, Maryland can begin to offer parents new assurance that everyday consumer products are safe to bring home from the store and to use in caring for their families.

Alternatives to Formaldehyde Are Readily Available

Many companies across the U.S. are using healthier building materials and developing safer alternatives to replace toxic products. Columbia Forest Products provides a good example.

In 2005, Columbia Forest Products, North America's largest manufacturer of hardwood plywood and hardwood veneer, announced its transition to PureBond®, a manufacturing technology that utilizes a natural adhesive composed primarily of soy flour and water.[83] Scientists designed the formula "to mimic the protein that marine mussels use to attach themselves to rocks and other hard surfaces."[84]

By March 2008, the company had converted all seven of its manufacturing plants to use this system, producing more than 25 million

plywood panels with formaldehyde-free adhesive.[85] The conversion replaced millions of pounds of urea-formaldehyde, reducing emissions of hazardous air pollutants at the plants by up to 90 percent.[86]

Plywood panels made with PureBond® already comply with the most stringent formaldehyde emissions limits put forward by the California Air Resources Board.[87] Moreover, they cost no more than panels made with the standard urea-formaldehyde adhesive.[88] In 2007, U.S. EPA recognized Columbia Forest Products for this achievement with a Presidential Green Chemistry Challenge Award.[89]

Other alternative adhesives are available to manufacture particle board and fiber board with ultra low formaldehyde emissions.[90] In addition, everyday building materials – such as stone, brick, metal, glass, and solid wood – are generally formaldehyde-free. Furniture, cabinetry and buildings made of these materials do not emit formaldehyde.

Maryland should ensure that manufacturers identify and prioritize safer alternatives to many different varieties of toxic chemicals, much as Columbia Forest Products has done with formaldehyde-based adhesives.

POLICY RECOMMENDATIONS

Comprehensive chemical regulatory reform is necessary to improve our knowledge of chemicals used in commerce, encourage the use of materials and processes most likely to be safe, and enable the government to take action to protect public health and the environment from the greatest threats, when warranted. In order to protect children from toxic exposures, Maryland should:

Require chemical manufacturers to prove that a chemical is safe before allowing it on the market.

- Regulators should require companies to provide comprehensive data on the intrinsic hazards of chemicals that they produce or import into Maryland. Such data should include information on a chemical's ability to persist in the environment, accumulate in living organisms, be metabolized into other hazardous compounds, cause genetic damage, mimic important hormone signals, interfere with human development or reproduction, weaken the immune system, damage the nervous system, cause respiratory disease, or otherwise harm human health.
- Chemical testing should include specific consideration of potential impacts on infants, children, and pregnant women; potential impacts of low-dose exposures; and potential interactions with other toxic chemicals.
- The reliability and adequacy of the information should be validated by government scientists and/or an independent third party free of conflicts of interest.

Empower regulatory agencies to restrict or ban the manufacture and use of chemicals that pose potential dangers to human health or well-being.

- Where chemicals show evidence of intrinsic hazard – such as a tendency to persist in the environment, accumulate in living organisms, or cause toxic effects – regulators should restrict or prohibit the use of these chemicals and require the substitution of safer alternatives, particularly in consumer products or other applications that lead to human exposure. In addition, regulators should consider possible adverse impacts to ecosystems.

- Where there is uncertainty in the evidence, regulators should err on the side of protecting health and well-being.

Ensure public access to information on chemicals and their uses.

- The public has a right to know about chemicals currently on the market, including their specific uses, potential hazards to health and the environment, and potential exposures. Maryland should create an easily understood database for all chemicals currently in use. This tool would enable businesses and consumers to compare the safety of chemicals, identify missing data, and create demand for safer alternatives.
- Until health and safety data are available for a particular chemical, there should be mandatory labeling for consumer products indicating the presence of a chemical that has not been tested for its impact on human health.

Recommendations for Consumers to Avoid Formaldehyde Exposure

Consumers seeking to avoid formaldehyde exposure face many obstacles. Products made with formaldehyde are very unlikely to be labeled as such. Even well-educated consumers consciously looking for healthy products may find that a seemingly innocuous product actually emits formaldehyde. For example, Dr. Mark Mendell, an indoor air quality expert at the Lawrence Berkeley National Laboratory, chose bamboo when remodeling the floor in his home. He later discovered that the bamboo floor was releasing formaldehyde vapor, likely from a urea-formaldehyde adhesive.[91]

To reduce the risk of exposure to formaldehyde in the home, consumers should:

- Ask retailers and manufacturers about the formaldehyde emissions of products, including furniture, cabinetry and building products made of composite wood, before you purchase them.
- If information about formaldehyde emissions is unavailable, avoid products with components made of medium density fiberboard, particleboard or other types of composite wood. Look for product descriptions that indicate the use of solid wood, which does not contain formaldehyde.
- Maintain moderate temperature and humidity levels and provide adequate ventilation within your home. Formaldehyde emissions are accelerated by heat, and also somewhat by humidity. Adequate ventilation with outdoor air can help to prevent formaldehyde and other indoor air pollutants from building up to greatly elevated levels within your home.
- Place pollution-absorbing plants in your home. For example, scientists have demonstrated that spider plants (*Chlorophytum elatum*), Boston ferns (*Nephrolepis exalta Bostoniensis*), dwarf date palms (*Phoenix roebelinii*), pot mums (*Chrysanthemum morifolium*), and peace lilies (*Spathiphyllum*) can effectively reduce formaldehyde levels in indoor air.[92]

METHODOLOGY

FORMALDEHYDE EMISSION TESTING

Environment California Research & Policy Center contracted with Berkeley Analytical Associates, LLC in Richmond, California, to test 21 baby nursery furnishings for their formaldehyde emissions. The firm is a commercial laboratory specializing in the measurement of chemical emissions from building materials, architectural finishes, and furniture using large and small scale environmental chambers. Their services are available to industry, governmental agencies, and professional organizations.

The laboratory placed each product into a large or small scale chamber operated under controlled conditions according to ASTM Standards D 5116 and D 6670. Products were taken from their packaging and transferred directly to the chambers. Many of the large pieces were tested in unassembled or partially assembled configuration.

Conditions within the chamber were set to approximate the indoor environment. Temperature ranged from 22°C to 24°C. Relative humidity ranged from 45 to 55 percent. Air within the chamber was changed once per hour by ventilation. After 24 hours, air samples for formaldehyde were collected from the chambers. The samples were analyzed for formaldehyde by High Performance Liquid Chromatography following ASTM Method D 5197, with a limit of detection of about 1 microgram per cubic meter.[93]

The laboratory reported the results for each product in terms of an emission factor, in units of micrograms of formaldehyde emitted per product unit per hour, according to Equation 1, where Q is the rate of air flow into the test chamber (in cubic meters per hour), C is the measured concentration of formaldehyde in the test chamber (in micrograms per cubic meter), Co is the chamber background concentration of formaldehyde before the product was added, and N is the number of units of product added to the testing chamber.

Equation 1:

$$\text{Emission Factor} = \frac{Q * (C - C_0)}{N}$$

INDOOR AIR QUALITY MODELING

Using the results of the testing, Frontier Group estimated the contribution each product would have toward whole-house formaldehyde concentrations.

Frontier Group used Equation 2 to estimate indoor formaldehyde levels, where EF is the measured emission factor of the product (in micrograms per unit per hour), N is the number of units, V is the interior volume of the home (in cubic meters), and A is the ventilation rate (in air changes per hour). The resulting concentration in micrograms per cubic meter was converted to ppb by multiplying by 0.813, per the Agency for Toxic Substances and Disease Registry (ATSDR), *Toxicological Profile for Formaldehyde*, July 1999.

Equation 2:

$$\text{Indoor Concentration} = \frac{EF * N}{V * A}$$

Frontier Group used a set of assumptions describing the size and ventilation rate of four generic types of North American residences, per Alfred T. Hodgson, Berkeley Analytical Associates, LLC, *Residential Exposure Scenarios for Estimation of the Impacts of Products on Indoor Air Quality*,

20 September 2007. Table 5 lists these assumptions.

Table 5: Size and Ventilation Rates for Four Generic Types of Residences[94]

	Home Volume (cubic meters)	Ventilation Rate (full air changes per hour)
Existing Single Family Home	340	0.5
New Single Family Home	536	0.24
Existing Unit in Apartment Building	204	0.5
New Unit in Apartment Building	260	0.29

APPENDIX: DETAILED PRODUCT IDENTIFICATION AND TESTING RESULTS

Product Name	Product Sample ID	Manufacturer ID
Child Craft Oak Crib with Storage Drawer - Oak	ASIN: B000BV3I1Q	Catalog #10182136
Bridget 4-in-1 Crib (White)	Item #8021348771	Wal-Mart #002638982
Kayla II Changing Table – Natural	Item #95971	00525-72N; SKU: 517E7D45
Cherry Berkley Ready-to-Assemble Changing Table	#572982	0603G00WP
Pure White Country Style Changing Table	Catalog #663615	3580330
Rochester Cognac Crib with Drawer	Catalog #551420	04550-92C
Nursery-In-A-Box Crib (Cherry)*	Item #74102289003	Wal-Mart #002653394
Natural Americana Lifetime Crib	Item #666974	DJ203B4NWP; SKU 57DF2C35
Graco Lauren 4-in-1 Dropside Convertible Crib - Natural	Catalog #10456405	Model #3150282
Baby Cocoa Valance	Jungle Animals Style	Item #31663
Football Wall Shelf	Catalog #695759	Item #100339
Alphabet Soup Decorative Waste Basket	Item #882841	7110109, SKU: F9E9BB53
South Shore Changing Table - Natural Maple	Item #584484	2713-330; SKU: 32836556
Lady Bug Waste Basket	UPC 7 89887 274116	Style #7001WTC
Sugar Plum Lamp Base & Shade	Item #577615	716129; SKU: C3E05D08
Olympia Single Crib - Dark Pine	Item #292424	0102E00; SKU: AEEEBF16
Lambs & Ivy Froggy Tales Lamp	Item #87405	54024; SKU: A4123372
Alphabet Soup Wall Hanging	UPC 6 80601 00759 4	711037
Olivia Decorative Valance	Item #310066	5008V
Winnie The Pooh Wall Shelf with Pegs	UPC 85214 00346 7	1400989 DB Wall Shelf
My First Doll	UPC/EAN/ISBN 7 17851 15078	Style #3415078; PA #5248 (RC)

*We tested the crib only, not the dresser or the table that also came with this product.

Manufacturer	Retailer	Formaldehyde Emissions (micrograms per unit per hour)	Existing Single Family	New Single Family	Existing Apartment	New Apartment
Child Craft	Target	3,680	17.6	23.3	29.4	39.8
Delta	Wal-Mart	1,670	8.0	10.6	13.3	18.1
Storkcraft	Babies R Us	1,090	5.2	6.9	8.7	11.8
Jardine Enterprises	Babies R Us	974	4.7	6.2	7.8	10.5
South Shore Furniture	Target	662	3.2	4.2	5.3	7.2
Storkcraft	Target	573	2.7	3.6	4.6	6.2
Simplicity for Children	Wal-Mart	69	0.3	0.4	0.5	0.7
Jardine Enterprises	Babies R Us	62	0.3	0.4	0.5	0.7
Graco	Target	36	0.2	0.2	0.3	0.4
Lambs & Ivy	Babies R Us	16	0.1	0.1	0.1	0.2
Trend Lad	Target	11	0.1	0.1	0.1	0.1
CoCaLo	Babies R Us	9	0.0	0.1	0.1	0.1
South Shore Furniture	Babies R Us	8	0.0	0.1	0.1	0.1
Kids Line	Babies R Us	6	0.0	0.0	0.1	0.1
CoCaLo	Babies R Us	6	0.0	0.0	0.0	0.1
Jardine Enterprises	Babies R Us	<6	0.0	0.0	0.0	<0.1
Lambs & Ivy	Babies R Us	5	0.0	0.0	0.0	0.1
CoCaLo	Babies R Us	4	0.0	0.0	0.0	0.0
Kids Line	Babies R Us	4	0.0	0.0	0.0	0.0
Crown Crafts Infant Products, Inc.	Babies R Us	3	0.0	0.0	0.0	0.0
Koala Baby	Babies R Us	1	0.0	0.0	0.0	0.0

NOTES

[1] U.S. Consumer Product Safety Commission, *Infant/Child Product Recalls (N*ot *Including Toys)*, downloaded from www.cpsc.gov/cpscpub/prerel/category/child.html on 10 March 2008.
[2] Janine Brady, et al., "Toy Contaminated with 'Date Rape' Drug Pulled," *CNN*, 8 November 2007; available at www.cnn.com.
[3] U.S. Consumer Product Safety Commission, *Infant/Child Product Recalls (N*ot *Including Toys)*, downloaded from www.cpsc.gov/cpscpub/prerel/category/child.html on 10 March 2008. Lead impacts: U.S. Centers for Disease Control and Prevention, *A Review of Evidence of Adverse Health Effects Associated with Blood Lead Levels <10 µg/dL in Children*, Appendix A in: *Preventing Lead Poisoning in Young Children*, August 2005.
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[6] U.S. Environmental Protection Agency, *Chemical Hazard Data Availability Study*, 1998. Major chemicals are defined as those produced or imported in amounts exceeding one million pounds per year.
[7] Commission of the European Communities, *White Paper: Strategy for a Future Chemicals Policy*, COM(2001) 88 final, 27 February 2001; Carcinogenic, mutagenic, and reprotoxic chemicals, plus chemicals defined as category 1 or 2 in EU Directive 67/548, plus persistent organic pollutants.
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[13] Ibid.
[14] Al Hodgson et al., "Volatile Organic Compound Concentrations and Emission Rates in New Manufactured and Site-Built Houses," *Indoor Air* 3:178-192, 2000.
[15] See Note 12.
[16] US EPA, *Sources of Indoor Air Pollution – Formaldehyde*, downloaded from www.epa.gov/iaq/formalde.html, 27 March 2006.
[17] T.J. Kelly, et al., "Emission Rates of Formaldehyde from Materials and Consumer Products Found in California Homes," *Environmental Science and Technology* 33: 81-88, 1999.
[18] US EPA, *Sources of Indoor Air Pollution – Formaldehyde*, downloaded from www.epa.gov/iaq/formalde.html, 27 March 2006.
[19] Ibid.
[20] See Note 12.
[21] Toxics Use Reduction Institute, *Toxics Use Reduction Act Reports: Report for Massachusetts as a Whole, 2001*, downloaded from turadata.turi.org on 9 April 2004.
[22] For example, see diethylhexyl-phthalate or butylbenzyl- phthalate: Toxics Use Reduction Institute, *Toxics Use Reduction Act Reports: Report for Massachusetts as a Whole, 2001*, downloaded from turadata.turi.org on 9 April 2004.
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[25] Lowell Center for Sustainable Production, *Formaldehyde Fact Sheet*, March 2003.
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[33] IARC is part of the World Health Organization. Its mission is to coordinate and conduct research on the causes of human cancer and to develop scientific strategies for cancer control. As part of the California Environmental Protection Agency, OEHHA's mission is to protect and enhance public health and the environment through the scientific evaluation of risks posed by hazardous substances. Carcinogen listings: U.S. EPA Technology Transfer Network Air Toxics Website, *Formaldehyde: Hazard Summary – Created in April 1992: Revised in January 2000*, 09 March 2006; International Agency for Research on Cancer, *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, 88(2-9), June 2004.
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[38] See Note 11.
[39] Marla Mueller, University of California, Berkeley, *Ventilation Characteristics of California Homes*, ARB Contract No. 03-326, June 2007.
[40] Francis Offerman et al., Indoor Environmental Engineering, San Francisco, CA, *Window Usage, Ventilation, and Formaldehyde Concentrations in New California Homes: Summer Field Sessions*, November 2007.
[41] Alfred Hodgson, Berkeley Analytical Associates, LLC, *Residential Exposure Scenarios for Estimation of the Impacts of Products on Indoor Air Quality*, 20 September 2007.
[42] Ibid.
[43] 16 ppb: M.H. Garrett et al., "Increased Risk of Allergy in Children due to Formaldehyde Exposure in Homes," *Allergy* 54, 330–337, 1999; 50 ppb: K.B. Rumchev et al., "Domestic Exposure to Formaldehyde Significantly Increases the Risk of Asthma in Young Children," *European Respiratory Journal* 20, 403–408, 2002.
[44] This estimate makes simplifying assumptions, essentially treating the bedroom as if it were a small independent dwelling with a 40 cubic meter volume and a ventilation rate of 1 air change per hour, and using Equation 1 on page 30.
[45] State of California, Office of Environmental Health Hazard Assessment and Air Resources Board, *Final Report on the Identification of Formaldehyde as a Toxic Air Contaminant*, January 1992.
[46] This determination is part of California's Proposition 65 regulations. In contrast to Maryland, the state of California has taken steps to give consumers more information about chemicals, which has helped drive regulatory action and give the public more information about chemical exposure. Enacted in 1986, Proposition 65 requires businesses to inform the public of potential exposure to toxic substances officially recognized by the state as harmful. Businesses typically comply by posting warnings of potential exposures on product labels and on business premises. The state regularly updates the official list of recognized toxic chemicals based on new scientific information and makes the list publicly available. See: State of California, Office of Environmental Health and Hazard Assessment, *Proposition 65 Safe Harbor Levels: No Significant Risk Levels for Carcinogens and Maximum Allowable Dose Levels for Chemicals Causing Reproductive Toxicity*, January 2008.
[47] State of California, Office of Environmental Health and Hazard Assessment, *Proposition 65 Safe Harbor Levels: No Significant Risk Levels for Carcinogens and Maximum Allowable Dose Levels for Chemicals Causing Reproductive Toxicity*, January 2008.
[48] California Code of Regulations, Sections 12705 and 12805.
[49] See Note 12.
[50] Statewide, Maryland's cancer hazard rating from formaldehyde is 8.5, compared to 9.7 in California. See Green Media Toolshed, *Scorecard.org: Pollution Locator: Hazardous Air Pollutants: Chemicals*

Contributing to Estimated Cancer Risk, downloaded from www.scorecard.org on 2 June 2008.
[51] See Note 47.
[52] Tracey Woodruff et al, U.S. Environmental Protection Agency, "Trends in Environmentally Related Childhood Illnesses," *Pediatrics* 113: 1133-1140, April 2004.
[53] Commission of the European Communities, *White Paper: Strategy for a Future Chemicals Policy*, COM(2001) 88 final, 27 February 2001; Carcinogenic, mutagenic, and reprotoxic chemicals, plus chemicals defined as category 1 or 2 in EU Directive 67/548, plus persistent organic pollutants.
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[55] See Note 16.
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[58] Federal Panel on Formaldehyde, "Report of the Federal Panel on Formaldehyde," *Environmental Health Perspectives* 43: 139-168, 1982.
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[62] Consumer Product Safety Commission, *An Update On Formaldehyde: 1997 Revision*, CPSC Document #725, 1997.
[63] California Air Resources Board, *Proposed Airborne Toxic Control Measure for Composite Wood Products*, (factsheet), July 2006.
[64] Marla Cone, "U.S. Rules Allow the Sale of Products Others Ban: Chemical-Laden Goods Outlawed in Europe and Japan Are Permitted in the American Market," *Los Angeles Times*, 8 October 2006.
[65] Europe's E1 standard is about half of the HUD standard for plywood and particle board. Japan's F standards are even more stringent, forcing new emissions-limiting technology for some products. California Air Resources Board, *Airborne Toxic Control Measure on Composite Wood Products*, Presented at a Public Workshop, Sacramento, CA, 20 June 2006.
[66] See Note 64.
[67] California Air Resources Board, *Proposed Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products* [Board Presentation], 26 April 2007.
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[75] See Note 5.
[76] See Note 7.
[77] See Note 6.
[78] Out of 413 chemicals tested for. Jane Houlian et al., Environmental Working Group, *Body Burden: The Pollution in Newborns*, 14 July 2005.
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[94] See Note 41.